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Cutting Spanish Cedar in the Island of Trinidad, showing the high stump that is left standing.

SPANISH CEDAR.—[See page 372.]

Rail Sections as an Element in Steam and Electric Traction—II*

Early History of Track Construction and Developments Made Possible

By P. H. Dudley, C.E., Ph.D., Consulting Engineer, New York Central Lines, New York

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2031, Page 363, December 5, 1914

STIFF AND HEAVY RAIL SECTIONS.

I designed a series of stiffer and heavier rail sections, after the demonstration and experience with the first 5-inch, 80-pound by the New York Central & Hudson River Railroad, of which the 6-inch, 100-pound section, rolled March 12th, 1892, had been described. The 5⅛-inch, 80-pound (Fig. 7), of which several hundred thousand tons have since been rolled, was over 10 per cent stiffer than the original 5-inch, 80-pound, and some of the first made in 1892 have just been replaced by the 100-pound.

I made all my sections with broad and thin heads joined to the web with ½-inch fillets and 12-inch radii for all sections under 70 pounds, and 14 inches for those which were heavier. The thinnest portion of the web was above the neutral axis, to form a larger function with the base.

QUALITY OF METAL IN THE RAILS.

When I increased the height of the sections to augment their stiffness for smoother tracks which would check the deflections and reduce the area of contact between the wheels and rails slightly, I knew it would be necessary to increase the physical properties of the metal in the stiffer rails to avoid rapid wear and deformation. I introduced, for that reason, the low phosphorus 0.06 and 0.56 to 0.65 carbon Bessemer steel for the heavier sections. The Boston & Albany rails were rolled in 1891 out of the tougher steel, and I obtained 12 to 16 per cent ductility in the metal under the drop test, which had become obsolete for testing rails until this reinstatement. The specifications were that if 90 per cent of the butts, one from each heat, should withstand a weight of 2,000 pounds falling 20 feet without fracture, and any of the remaining 10 per cent gave 4 per cent elongation per inch before breaking, the heat would be accepted. Less than 5 per cent of the heats failed under the 20-foot drop test. This high grade of steel was made for the New York Central and Boston & Albany railroads from 1891, and continued until the low phosphorus ores were exhausted in 1898.

The metal was tough and tenacious and had so large a duration strain factor that but few breakages occurred in the zero or lower temperatures of winter, and practically none in the summer. I rolled over 500,000 tons of such metal in three-rail ingots for 30-foot rails in the 80, 95, and 100-pound sections. I commenced in 1893 to mark the top rail "A," the second "B," and the third or last rail of the ingot "C." The subsequent service in the track furnished the first opportunity to study the wear of the rails from the different positions of the ingots. The practice of the use of a letter to designate the position in the ingot is general for the railroad companies of the United States for rails and some wheels and tires.

The "A" rails of Bessemer steel with a trace of entrained slag and oxides wore the most rapidly under heavy traffic, but the breakages were not much in excess of either "B" or "C" rails. It was this fact of the service tests of fourteen years that enabled me in 1907 to check the general adoption of a 20 to 25 per cent discard from the ingot. Improvements in making the steel and sound ingots to secure the full ductility of the metal due to its composition, is now the general practice and the wasteful discard is avoided.

REDUCTIONS OF UNDULATIONS IN THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD TRACKS, FROM 1881 TO 1914.

The undulations as summed up by the track indicator in 1881 on the New York Central and Boston & Albany railroads averaged 8 feet per mile, though there were some miles of 12½ feet, and others as low as 5 feet on new rails. The New York Central & Hudson River Railroad has a chart showing the reductions of undulations in the track from 1881 to 1907, as measured by my track indicator. A curve also shows the increase in driving wheel axle loads on the engines. It is instructive and shows that, as the stiffness of the rails increased, the average undulations of the track decreased from 8 feet per mile to 2¼ feet in 1900, while the driving wheel axle loads increased from 30,000 to 60,000 pounds before 1907. The undulations of the track for 1914 are estimated to average about two feet or less per mile. The reductions in undulations of the track, by the stiffer sections as better engineering structures, have lessened the generated wheel effects and enabled heavier wheel loads and trains to be run as steam railway traction progressed.

* Courtesy of the *General Electric Review.*

The Empire State Express was installed October 26th, 1891, with Mr. James Buchanan's 100-ton locomotive, and drew four cars of more than double its weight—the educator of the world for heavy high speed trains. The train to-day is three times its former weight and is composed of eight to ten Pullmans. Freight trains of ninety to one hundred cars of about 4,000 tons are now ordinary, as the train resistance is less per ton for long and heavy trains than for a single unit run by itself.

It is obvious that such progress in steam railway traction has been secured only by the utilization of important principles of construction of the equipment and the permanent way, which is apparent from observation and experience. There is, of course, difference of opinion for the reasons of the results, and the facts can be learned only by measuring the strains in the rails under the passing wheel loads.

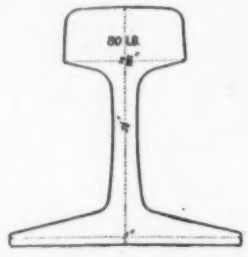


Fig. 7.—New York Central and Hudson River Railroad, 1892.

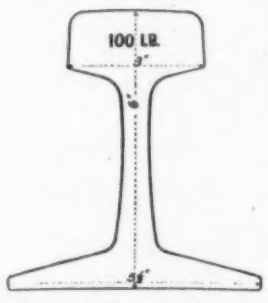


Fig. 8.—New York Central and Hudson River Railroad, 1892.

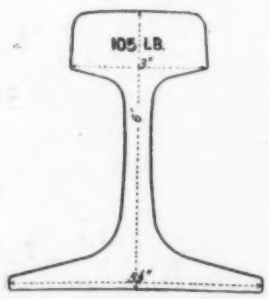


Fig. 9.—New York Central and Hudson River Railroad, 1912.

The original 100-pound section, to meet the progress in transportation, has been increased to a 105-pound section, by the addition of fillets of 1-inch radius to join the web and base, and the web thickened to five eighths of an inch without other changes in dimensions. This was for additional stiffness and strength, and the rolling of basic open hearth steel from 0.63 to 0.75 carbon (see Fig. 9). The new splice bars also fit the original 100-pound and thus join in the track the 100 and 105-pound rail sections.

THE EQUILIBRIUM DEPRESSION BETWEEN THE TRACK AND WHEEL LOADS OF THE PASSING LOCOMOTIVES AND CARS.

The moving wheel loads of the locomotives and cars depress the rails, crossties, ballast, and subgrade from the trackman's surface to the momentary equilibrium depression, and the specific deflections under the wheel contacts of the rails on the flexible crossties are limited by the strains produced in the metal of the section.

The depression is merely momentary for the rails, crossties, ballast and subgrade, for they return practically to the trackman's surface after the train passes.

THE STREMMATOGRAPH.

The stremmatograph is an instrument of precision which I designed, and completed its construction in 1897, to determine the unit fiber strains in the rails when attached to the base between the crossties under moving trains. It is the function of the stremmatograph to make autographic records of the longitudinal unit fiber strains of the elasticity in the metal of the rail section exercised in the base, due to the action of each individual moving wheel load, and its reactions on the flexible supports in the ballast and subgrade. The strains in the base are balanced in the head by those of an opposite character. The strains for a given unit length in the spans of the bending rail controlled by the wheel spacing of the equipment reverse above and below the neutral axis of the section for each passing wheel as a rule, consequently there is a series of alternating unit fiber strains to balance the stresses set up in the metal of the section to carry the wheel load effects. The unit fiber strains or balanced stresses developed in two different rail sections as simple beams of like sections on rigid supports and load are inversely proportional to their respective moments of inertia, according to the laws of mechanics.

The tests on 80 and 100-pound rails with the stremmatograph show for the entire wheel base of the same locomotive with smooth wheels, that the above law of mechanics is equally true for the sum of all the unit fiber or balanced stresses per individual wheel, in two rail sections of different moments of inertia, on the flexible crosstie supports in the equilibrium depression of the track, until a speed is reached where the weaker section develops wheel effects in a faster ratio than the stiffer rails. The track construction and roadbed must be similar for both sections of rails (see Fig. 10).

The comparative tests were made on the New York Central & Hudson River Railroad at Coldwater, N. Y., July, 1913, upon a worn 5⅛-inch, 80-pound rail rolled in 1892 and laid in track No. 3, and a worn 6-inch, 100-pound rail rolled in 1905, and laid in track No. 4, by the side of track No. 3. The worn 80-pound rails had carried over 300,000,000 tons, and the worn 100-pound, 135,000,000 tons. The moment of inertia of the 80-pound rail had been reduced from 28.5⁴ inches to 26.3⁴ inches, according to the profile of the head, and were 30-foot lengths spliced with 36-inch angle bars for a three-tie supported joint. The moment of inertia of the 100-pound had been reduced from 48.5⁴ inches to 46.77⁴ inches, while the rails were 33 feet long and spliced with 36-inch bars for a similar joint to the 80-pound rail.

The ballast was gravel under each track, and the tests were made against the direction of the traffic on the 80-pound rail owing to conditions beyond control, but with it on the 100-pound rail.

The engine was a Mikado; the wheel base was 2-8-2; the total weight of the locomotive was 491,300 pounds; and the total length of wheel base was 68 feet 11 inches. Its tender had the usual two pairs of four-wheel trucks, a total of ten wheel contacts upon one rail. The locomotive was nearly new; the drivers and wheels were of normal rotundity, which rendered possible speeds from 6½ to 60 miles per hour, without the generation of large wheel effects.

The total stresses of each of eight tests upon the worn 5⅛-inch, 80-pound for one rail, and six tests upon the worn 100-pound rails for a range of speeds from 6½ to 45 miles per hour—140 different wheel effects for the two sections—compare within 1.52 per cent of being inversely proportional to the moments of inertia of the worn rails. Single experiments upon each section of rail for the same speed are within less than 1 per cent of the theoretical comparison. This is proof that the metal in the 80-pound section after its twenty-one years of service, owing to its quality, has not deteriorated in elastic properties in the slightest degree.

These tests involve also another law of the moving locomotive, ascertained by the stremmatograph, namely, the moving locomotive as a machine on good track, distributes its total load through its center of gravity to the several but individual wheel contacts on the rail. Fig. 10 shows the comparative diagrams of the average total stresses for the eight tests on the 80-pound, and six tests on the 100-pound rail. The mean of the total stresses per test on the 100-pound rail was 157,600 pounds, and on the 80-pound, 271,261 pounds, and would be double in each case for both rails of the track.

The diagrams show the comparative value of the two sections as engineering structures, for the crossties, ballast, and subgrade receive greater intensity of pressures, and must furnish more support for the 80-pound than is required for the 100-pound rails. The capacity and stability of the track of 80-pound rails is less than that of the 100-pound, and therefore exacts more labor in maintenance, for in the practice of engineering the roadbed is strengthened by the 6-inch, 100-pound rail. The rail section on its flexible crosstie supports with its several distributed wheel loads, by the experimental proof in the track of the stremmatograph, follows the laws of mechanics for a single deflection, with the advantage of the acquired constraint per wheel, and it is one reason why, mechanically, that it has been possible to secure the present progress in steam railway traction.

Jervis's principle of subdivided and distributed loads has empowered, without injury to the rails and roadbed, the use of a heavier total load for adhesion and expended tractive effort to be distributed through several wheel contacts for locomotives and electric motors, than was formerly possible through a single pair of drivers, or the 4-4-0 class of locomotives. The wheels of the engine and tender must be included for the total stresses of the steam locomotive, therefore the tender running gear must be included for the wheel effects for each class of locomotives. The 4-4-0 would have the following designation: 4-4-0 + 4-4, or eight wheel contacts on one rail. This class has been superseded by the 4-4-2 + 4-4 for heavy passenger service, and this in

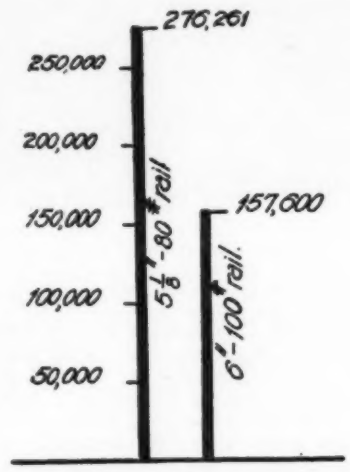


Fig. 10.—Comparison of total stresses on worn 5⅛-inch, 80-pound and worn 6-inch, 100-pound rails under the same locomotive. New York Central and Hudson River Railroad, July, 1913.

turn by the 4-6-2 + 4-4 class. There are a number of railways with mountain gradients and rails of 90-pound or less per yard where the class of locomotives of 4-8-2 + 4-4 is used to advantage. For freight service of slower speeds and larger train loads, the Mikados of 2-8-2 + 4-4 are in general use, and a class of 2-10-2 + 4-4 are employed when a larger tractive effort is required. The loading and constraint of the rails in the equilibrium depression would be still better with a class of 4-10-2 + 4-4 wheel base and drivers about 57 inches in diameter.

BASIC OPEN HEARTH RAILS.

The progress in transportation during the past few years has required the replacement of Bessemer rails of 0.10 phosphorus and 0.50 carbon, by basic open hearth steel of 0.04 phosphorus and 0.63 to 0.75 carbon, for 100-pound rails or over, to secure a duration strain factor of the metal which would carry the high speed trains in temperatures of 30 degrees below zero without fracture of the rail, as so frequently occurred in Bessemer steel.

The unit fiber stresses of 18,000 to 20,000 pounds under a driver of 30 miles per hour would be applied from zero to the full amount in about 0.04 of a second, and at 60 miles per hour it would be 0.02 of a second from measurements by the stremmatograph. This is quick time for the application and distribution of such large unit fiber strains which are balanced by the limited stresses set up in the metal. The basic open hearth rails, from the experience with them in the track, prove to have a greater duration strain factor in the metal than it was possible to secure in all of the 0.10 Bessemer steel rails at the low temperatures. The rails are made under the specifications for the New York Central Lines elongation and ductility tests for basic open hearth steel rails which were introduced in 1910, to secure those of the maximum ductility, purity, and homogeneity of the steel, due to its chemical composition for service in temperatures 40 degrees below zero F.

The drop tests are made from each melt, one from the crop of the top bar of the second, middle and last full ingot. The crop, 4 to 6 feet long, is stamped with a spacing bar of six 1-inch spaces in the center of its length on the base, head or side, as desired.

Each butt for basic open hearth rails for acceptance of the melt, must show under the drop of 18 feet for the 80 and 90-pound sections, and 20 feet for the 100-pound section, at least 6 per cent elongation for one inch, or 5 per cent for two consecutive inches before fracture. The elongation of each of the six spaced inches is measured by a flexible rule, divided into hundredths of an inch, therefore the increased one-hundredths after the drop give the percentage of elongation per inch of the metal. The ductility is completely exhausted in one test for each metal, and is made in rotation from the different ingots in succeeding melts. The melter has the ductility of the last melt before he taps another from the same furnace, which has enabled a greater uniformity of the steel to be obtained than was possible before the tests. The specifications for the ductility tests have been adopted by the American Railway Engineering Association for use by the railroads in the United States.

THE WHEEL PROBLEM.

The wheel consists of a tread constructed of uniform radius revolving upon its axis of lesser rolling and with less axle friction than would be produced by sliding on its support, and is the mechanical embodiment of a principle for transportation so ancient that its origin is unknown. The wheels and drivers are the only contacts on the rails to support and carry the equipment, and it is requisite that the material of their treads should be homogeneous and able to maintain their rotundity for a considerable length of service.

A 36-inch wheel makes 560.2 revolutions per mile and for a static load of five tons the repetitions upon the metal of the tread are equivalent to 2,801 tons per mile. To run from New York to Chicago, the applied static tons per mile equal 2,718,164 mile-tons per wheel for the trip, exclusive of generated wheel effects.

The New York Central Lines are giving special attention to the wheel problem by measuring the wear and deformation on thousands of sections of marked wheels to secure a metal in the wheel treads which will maintain their rotundity under the large mile tons of service and the action of the brakeshoes to control the trains.

ELECTRIC TRACTION.

The principles and practice elucidated by the stiff rail sections for steam railway practice apply equally to electric traction. The latter has the advantage for city traffic, for imbedded girder rails on rigid supports with welded joints can be used to carry millions of tons of traffic before the track requires adjustment or renewal of the rails.

Electric traction has rendered possible the large underground terminals like the New York Central & Hudson River, the Pennsylvania, and the Hudson & Manhattan railroads, and the subways in New York city. The ten and twelve-car multiple unit trains with two to five minutes headway, and all the appliances for safety of control in their movements, are models of electric traction.

The trolleys in the cities and country roads are usually contructed with light T rails which could be replaced with advantage by stiffer sections.

The electrical engineers have the unique problem of developing motors on similar principles to those that determined the evolution of the steam locomotive.

RESISTANCE OF STEEL RAILS AS ELECTRIC CONDUCTORS.

The 70-pound contact rails for the Grand Central Terminal were made of Bessemer steel in 1905, and continue to the present time, of the following desired composition:

Carbon	0.10
Manganese	0.40
Silicon	0.05 or less.
Phosphorus not to exceed	0.10 and as much less as possible.
Sulphur not to exceed	0.08 and as much less as possible.

The manganese was just sufficient to roll the steel which gave a resistance of 8 to 8½ times that of copper. The resistance in some of the recent Bessemer 70-pound contact rails is from nine to ten times that of copper, though the higher figure is from the upper part of the ingot, and doubtless was rolled cold. The resistance of a 70-pound New York Central & Hudson River Railroad standard section of the ordinary composition for the rail was 12.5 times that of copper; of the 100-pound Bessemer, 11 to 12 times; while the 105-pound section in basic open hearth steel is only about 10.6 times.

Basic open-hearth 70-pound contact rails can now be obtained of about 0.10 carbon, but with phosphorus and sulphur each under 0.04, in which the resistance is guaranteed to be not over seven times that of copper. This needs confirmation for the steel of the entire ingot.

The strap iron rail with its 6 by 6 inch wooden stringer for the girder of the Mohawk & Hudson Railroad of 1831, and the 6-inch steel section of 1892, are historic illustrations of the progress of railway transportation as governed by the rail section.

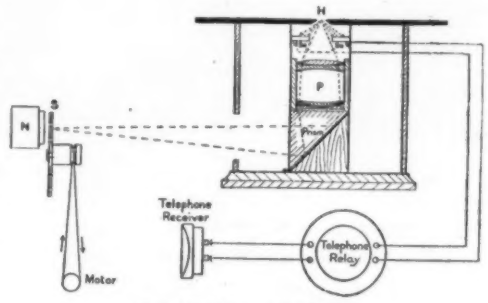
The Type-Reading Optophone*

By E. E. Fournier d'Albe

ANY instrument designed for translating optical into acoustic effects, or light into sound, and thus to some extent substituting the ear for the eye, may be appropriately termed an "optophone." The intermediate link is either heat or electric current, and in view of the fact that a current of a few thousandths of a microampere is audible in the best modern telephones (if intermittent), one would naturally use an electrical rather than a thermal link. This is done in the various forms of "optophone" devised by the author since the Optical Convention of 1912.

The latest of these, described before the Royal Society on May 28th, and shown at the conversazione of the society on June 16th, is designed with the object of enabling blind persons to "read" ordinary letterpress by means of the ear. The accompanying illustration of the optical arrangement is reproduced from the Royal Society paper by permission of the council.

An optical system throws the image of a glowing Nernst filament upon the printed paper, laid face downward on a suitably perforated desk. This image is broken up into a series of seven or eight luminous dots, flashing with different musical frequencies, by means of a rotating siren placed immediately in front of the Nernst filament. Some light-sensitive preparation, preferably of selenium, is placed close to the type so as to receive whatever light is diffusely reflected by it.



Type-reading optophone.

N, Nernst lamp; *S*, rotating siren disk; *P*, portrait lens, throwing image of line of intermittent dots on the printed matter placed face downward at *H*; Se, selenium preparation receiving diffusely reflected light.

The size of the image is made to fit the kind of type to be read, and a sensitive telephone is put in series with the selenium and a battery with one of S. G. Brown's telephone relays.

It has been found possible to obtain an "audible" sound from type of the ordinary newspaper size. The straight black stem of a letter produces silence, and a curved letter, such as S, produces in its passage a set of gradually changing notes which are characteristic of the letter, and cannot be mistaken even after only a few minutes' practice. To learn the entire alphabet in this way should be a matter of a few weeks or months, but the amount of practice required will vary very greatly from one person to another, as only a "musical" ear can readily detect the omission of certain notes from a given chord. Given an adequate alinement and line-changing mechanism, there is no reason why, with sufficient practice, ear-reading should not be almost as rapid as ordinary reading at sight.

The choice of type is, of course, unlimited. There is no arbitrary element in the determination of the sounds required to represent the various letters, as each type will automatically produce its own characteristic sounds. With considerable practice, a blind person, thus trained to allocate certain notes to certain positions, should be able to construct "instinctively" a visual (or tactile) image of any new or unfamiliar letterpress type at the first hearing.

Effects of the War on Employment in Germany

ACCORDING to figures recently published in Germany, about 21 per cent of the workmen of that country are out of employment. This estimate is based on reports made by a number of labor unions, and represents the average. In some trades as much as 62 per cent of the men are unemployed. The reports of thirty-four unions, with a membership of over a million and a half, from which only 1,269,000 replies were received to inquiries sent out, 268,459 were unemployed, and 2,254 others were wandering about the country seeking work. In the wood-workers association 24 per cent of its members were out of work, according to a census taken late in September.

* From *Nature*.

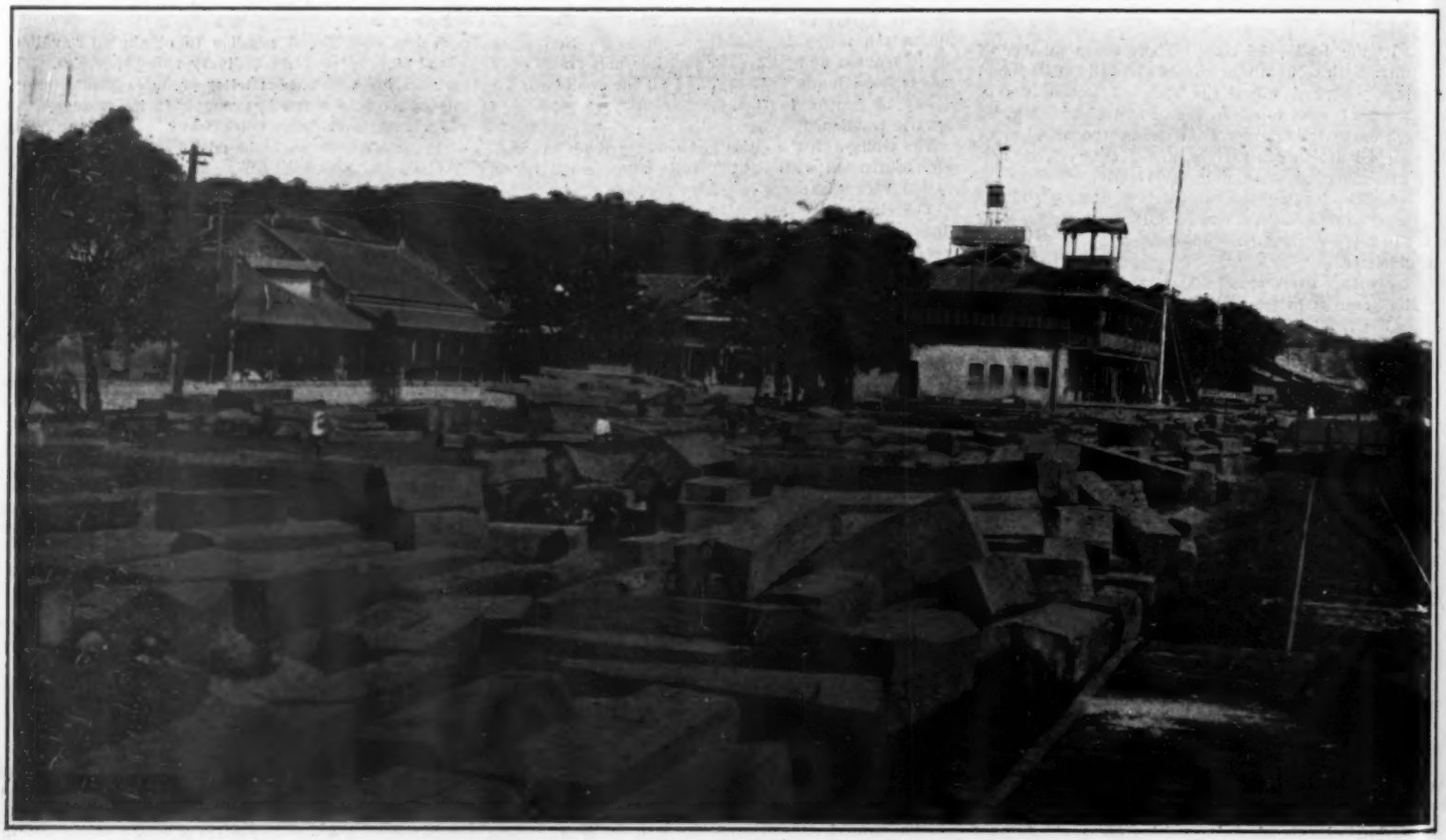
Logging scene in the cedar forests of the Island of Trinidad.

Spanish Cedar

Sources of Supply of this Substitute for Mahogany

SPANISH cedar (*Cedrela odorata*) is one of the standard woods imported from tropical America. There are a good many uses for which it is preferred to any other material, and it is a very satisfactory substitute for mahogany in many cases where figure is not an important object. It is eminently desirable that its supply should be regular and adequate to the demand, but for a long time now there has been a shortage of stock in Spanish cedar for making cigar boxes, its chief use in this country. The market is often practically bare of reserve stock, and the prices have advanced to such an extent that consumers have been obliged to seek other materials as substitutes. The principal woods now used in place of Spanish cedar for cigar boxes are the yellow poplar (*Liriodendron tulipifera*) and West African cedar of okume (*Boswellia klainiana*).

This condition is due chiefly to a scarcity of supply and the growing demand for the wood in the cigar-box industry. Both of these causes are operating together in pulling up the prices of this wood. The cedar territory is naturally becoming restricted and it is yearly more difficult to get out the logs. There was a time when Cuba, and comparatively small areas in low southeastern Mexico, turned out immense quantities of cedar. In Cuba it was the leading wood, being rivaled only by mahogany. But now the vast bulk of the mature trees have been cut away from all the sections where it was readily accessible, leaving the less accessible areas in Mexico, Central America, Trinidad, and Colombia to furnish the bulk of the supply. Cedar has been drawn in large quantities from southeastern Mexico, where there is a belt from twenty-five to one hundred miles wide; but the operations up to this time



Spanish cedar logs on the quay at Port-of-Spain, Trinidad, ready for shipment.

have resulted in clearing away the more accessible portions of the supply, leaving the remainder almost out of reach of the loggers. In a few places logging railroads have been put in, but for the most part dependence is placed upon the streams, and these are extremely uncertain except through the rainy season, when the logger must be in readiness with his supply of logs in order to get them to the place where they are loaded on steamers for shipment to the foreign markets.

The question of much interest to the dealers and consumers is as to whether the present supply and prices can be maintained. It is possible that new territory may be opened up in the interior portions of Mexico, which would bring an increased supply until the concession is exhausted. In view of the increased cost of logging under such circumstances there would be no possibility of lower prices than those that now prevail. Spanish cedar can not be cornered, and there is a great deal of it still left, but its location and the high cost of getting it out and transportation to market preclude any great enlargement in the supply or lowering the price. The various phases of this subject are identical with those which have governed the supply and price of true mahogany in the markets of the world.

Comfort for Workers in Washington's Government Buildings

Necessity for Modern Sanitary Conditions Now Being Recognized

By Day Allen Willey

MANY of the employees of the Government in Washington have been compelled to work day after day in dingy old buildings, walking up and down the steep stairways because no elevators would reach their offices. Typewriting, bookkeeping and performing of clerical work has been performed in ill-ventilated, dark offices with hard-back chairs or stools to sit on.

Considering the faithfulness and skill of these men and women, and their devotion to duty, the Government has been severely criticised in past years for keeping these workers in such uncomfortable and unhealthful offices. At last, however, some of the Senators and Congressmen have begun to give more thought to these thousands of toilers in the capital. As a result in the Department of Agriculture the majority of the army of busy workers for the interest of farmers now have offices in modern buildings of attractive design with roomy, well lighted apartments, ample toilet facilities and hooks for clothing, while elevators do away with the effort of climbing up and down stairs.

Another building that has been an eyesore of our capital was the Bureau of Engraving and Printing, where much of our currency is made. For years, workers have been crowded together in hot, dirty rooms, the floors greasy and stained with oil and littered with scraps of paper. The law compelled them to remain within the building the entire day for fear some employee might steal the valuable paper on which the bank bills are printed. Consequently, all the workers had to bring their noon lunches with them, and eat within the Bureau, finding a place where they could sit, such as an empty box, a stool or perhaps the stairways leading to the rooms.

Uncle Sam has at last given thought to these care-worn money makers and has provided a building for this bureau that is one of the most attractive in Washington, and is really a factory home in the many provisions made for the comfort of those who labor within its walls. The new structure consists of a main building of sandstone and the sides and ends of the wings are devoted almost entirely to windows, with the glass set in metal sashes. It has been estimated that 32,000 large panes of glass are required for the windows of the buildings.

The total floor area of the building is 476,700 square feet, and the cubical contents are about 7,000,000 square feet. In planning this new factory especial attention has been paid to the health and well-being of the employees.

A man who is well fed is in better condition to render good service than he who is in need of proper nourishment. Hence the installation of a co-operative lunch room in the new building. It is the duty of the physician in charge to supervise the sanitary conditions of the establishment. Each day he inspects the entire building, enforcing the utmost cleanliness, insuring every employee the necessary amount of ventilation in the room in which he works, studying lighting conditions and relieving eye strain. In addition he is always present to administer first aid to any in case of accident or relief in lesser ailments. In the new building pamphlets will be issued relating to the special illnesses likely to be met with in this sort of work.

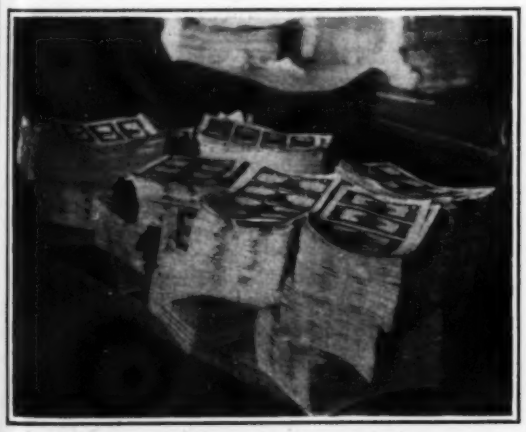
It has been planned that the employees shall operate the lunch rooms themselves. The Government has furnished all necessary equipment with the exception of dishes, silverware, linen and such accessories, which will be provided by the employees. An association of the workers has been formed for the purpose, women employees subscribing 50 cents each and the men $1 each. In this manner a fund of $2,000 has been raised. It is planned to refund the subscription as soon as the finances will permit. The lunch rooms are not to be operated as money-making propositions, and the food will be sold at the lowest possible figure.

Another advantage of the new bureau is that all of the mechanism is operated by electric motors except the preliminary work.

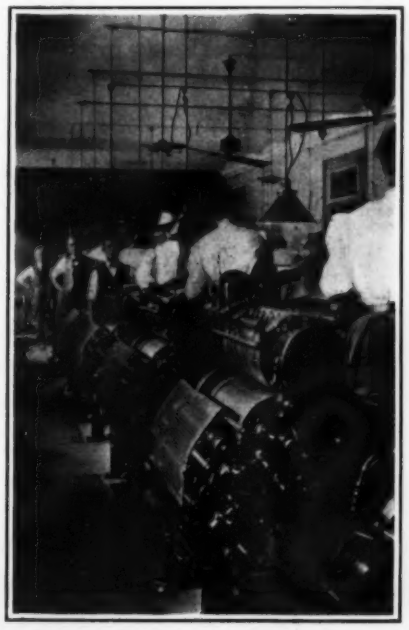
The methods of turning the sheets of linen paper into bills have been greatly improved in the new plant. First the sheets are dampened so that they will take a good impression from the printing press. Then they are placed upon presses where lettering and other characters are placed only upon the back. From these presses the sheets are taken to steam driers, where they are dried to set the printing ink. But before anything further is done, the sheets must again be moistened, after which they go to the electric printing presses and the front surfaces are lettered and stamped. After a further drying in the steam chests they are put upon the machines which place the number of each note in the proper position upon it.

The partly finished money is now ready for the counters. These are all women, and the rapidity with which they work is really wonderful, as the visitor sees them picking up sheet after sheet so rapidly that he can hardly distinguish one sheet from another. The counting is done to make sure that none of the money sheets have been lost or destroyed in any way; and after it is completed the currency in the form of sheets, each containing from four to eight notes, is ready to be carried in the big wagon to the Treasury.

At the Treasury there is very little work to be done by machinery except to put on each note what is called the seal. This is really a most artistic and beautiful piece of work, and is one of the most difficult designs to counterfeit. The sealing presses are operated by electrical machinery, and finish all of the currency issued through the national banks of the United States.



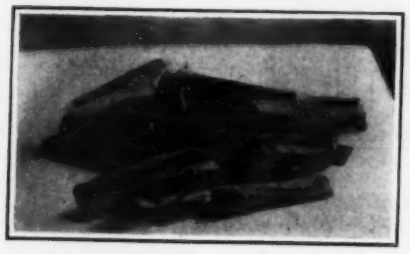
Half a million dollars in new notes.



Making money in Washington.

Numbering with colored inks on electric press.

Money in the vault ready for shipment to banks.



Charred bank bills sent for redemption.

Separating charred bank bills.

When the sealing is finished and the mechanical knives cut the sheets into the ordinary bank-notes, machinery has done its work; but in this building the money is counted and recounted so that there can be no possibility of a mistake.

On the second floor is a vault for the safe keeping of paper money after it has been completed and numbered. This vault is the most secure of any apartment in the building. The interior is about 50 by 20 feet and the ceiling 15 feet in height, with the walls constructed of reinforced concrete. Between the reinforced concrete portion of the walls and the outer coating is a mesh of electric wires. Should any of these be touched by an intruder, an alarm is automatically sounded in the office of the captain of the watch and also in the Treasury building many blocks distant.

An elaborate system of signals is employed in the building. There is a watchman's time detection system, with stations for reporting in each section of the factory, and in addition to a complete telephone system, there is another method for calling the various division superintendents to the office of the director. Another innovation is the division reporting system. By means of red, white and green lights the superintendent of each division will report to the captain of the watch at the closing hour whether his section is "clear"; that is, if every sheet of stamps or money and every printing plate has been accounted for at the conclusion of the day's work, and has been checked and sent into one of the vaults, the superintendent will operate a switch which will light the white bulb in the office of the captain of the watch. In case something is missing the red bulb will show a light, and this will order the division held until the missing article is accounted for.

In case of fire, on breaking the glass in any one of a score of stations an automatic device releases the pressure of a chemical engine, and a pipe system extending throughout the entire building is immediately filled with a chemically charged liquid such as is used in hand extinguishers. At twelve points on each floor a 75-foot hose is attached to the chemical system and a valve at the end of each pipe connection regulates the flow of the chemical.

The workers of the Bureau of Engraving and Printing have come to be known as the world's model working force. They manufacture enough paper money each day to carpet five acres, and the same force turns out enough postage stamps to stick on every inch of a six acre surface. Eleven acres might be covered with the revenue stamps they turn out each day. Of the 4,000 employees, there are 200 more women than men.

How to Determine Type of Motor*

Determining by the Leads Whether a Direct-Current Motor is Shunt, Series or Compound Wound

By F. A. Annett

"What kind of a machine am I working with?" is a question that often confronts the electrician or engineer. In the medium- and large-size machines (2 horse-power and up) this can usually be determined by inspection of the armature and field leads.

First, see if both the armature leads go to the external terminals, how many leads come from the field coils, whether they go to the external terminals; also, if there are small auxiliary poles (interpoles) between the main poles.

Assume a condition as in Fig. 1, where two leads come from the armature and two from the field coils which connect to four external terminals. If this machine is series wound, the armature and field leads will both be the same size, and of large cross-section. Sometimes, especially in small machines, one lead of the field is connected to one lead of the armature and only two terminals are brought out of the motor, as in Fig. 2. This does not alter the conditions, however.

If the machine is shunt wound, only the armature leads will be of large cross-section, while those of the field will be small, as indicated in Fig. 3. Also, the field terminals (lugs or connectors) will be small, while those of the armature terminals are large. On the series motor the field and armature terminals were large and of the same size. In some shunt motors a field and an armature lead are connected inside the machine and brought to the one terminal, as in Fig. 4. Again, in some very small machines the field coils are connected in multiple with the armature and only two terminals are brought out.

If the motor is compound wound, it will have two sets of fields. The series and the shunt coils are usually made up separately and placed on the polepieces, although in some cases the two coils are taped together before they are placed on the polepieces and look much like one coil, but they will always have four leads, two large and two small. These, together with the two armature leads, make six, which may be brought out to six terminals, as in Fig. 5; or one shunt and one series-field may be connected to the same terminal, as in Fig. 6. Again, one of the series-field leads may be connected directly to the armature (brush), as in Fig. 7, making only four external terminals. As far as the number of terminals required to connect the motor to the ordinary starting box is concerned, the other series-field lead and one of the shunt-field leads may be connected together, making only three external terminals, as in Fig. 8. In general practice, however, compound motors have five or six terminals, as in Figs. 5 and 6.

The large terminals are those of the series-field and the small ones those of the shunt field. This is very marked in the larger machines, the series-field often being made of copper bar. The series-field usually occupies from one-quarter to one-third the space on the polepieces occupied by the shunt-field coils, and may be placed either on the end of the polepieces near the armature or back against the frame.

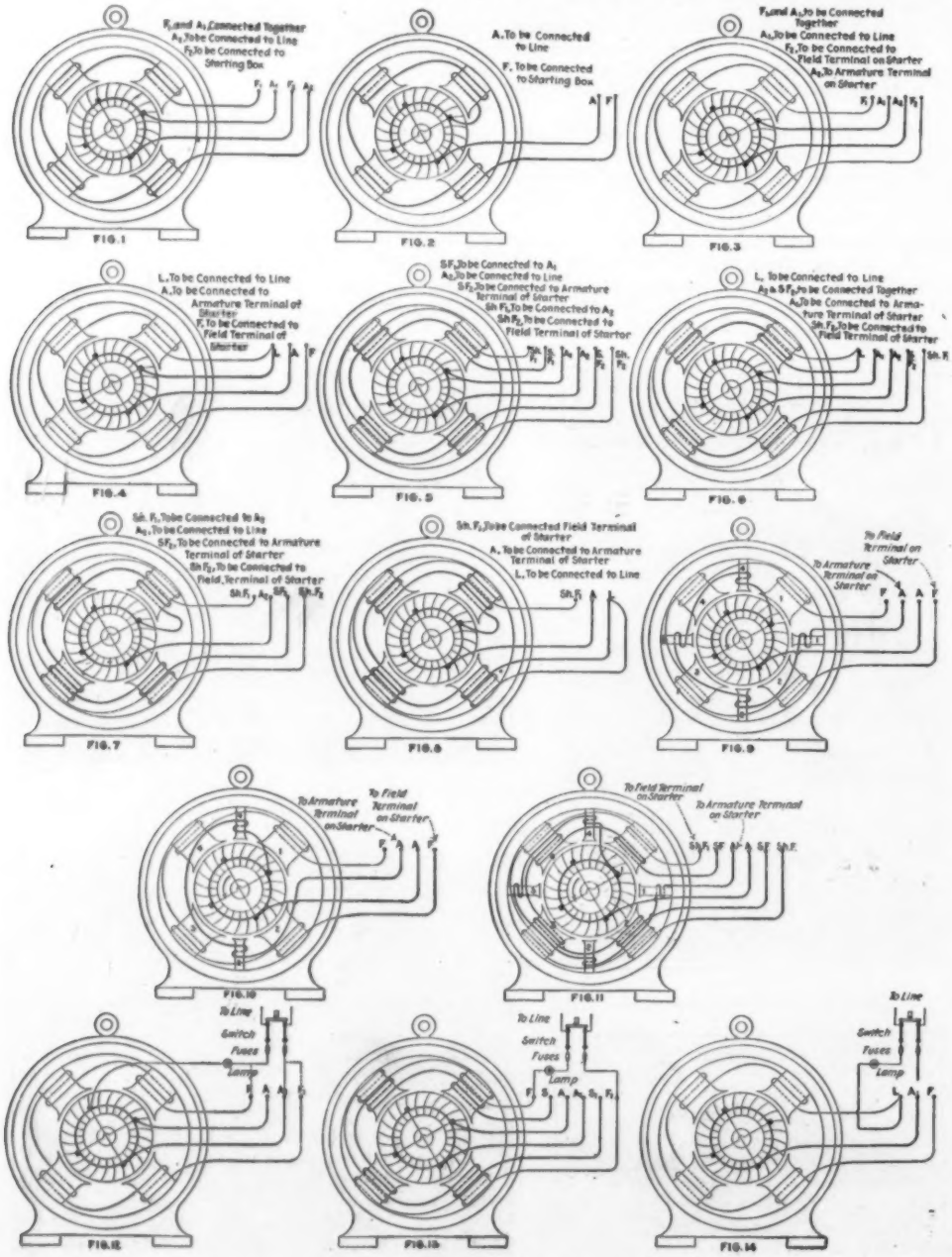
If the machine is of the interpole type—that is, with auxiliary poles between the main poles—the interpole winding will always be in series with the armature. Like the series-field winding, it is of large cross-section as represented by the heavy lines in Figs. 9, 10 and 11. Referring to these illustrations, it will be seen that an interpole winding does not necessitate any additional terminals on the outside of the machine as one lead of the interpole is connected to one armature lead, leaving but one armature and one interpole lead to be brought to the outside terminals.

In the different classes of machines considered, the armature windings are the same, each machine deriving its name from the field winding and its connections.

One thing that can be kept in mind is that a series motor is seldom used except in railway, electric-vehicle and crane service. In some cases, however, they are used to drive small pumps and blowers, but these are usually limited to sizes of 2 horse-power and less. It is on the small-size motors that it is the most difficult to distinguish the different types; for instance, by referring to Figs. 1 and 3, both motors have four terminals brought to the outside and in sizes below 2 horse-power the leads from both the armature and field coils are the same size, so it becomes necessary to make some kind of a test to determine whether the machine is shunt or series wound. This can be done by testing with a lamp.

First, place one terminal of the test circuit on the brushes, and with the other terminal connect to the various motor terminals until the lamp is lighted, as will be the case when connected as in Fig. 12. This will indicate an armature terminal. If one side of the test circuit is connected to terminals F or F_1 while the other side is connected to the brushes, the lamp will not light, as these are the field terminals, but when the test is made to

* Reproduced from *Power*.


F and A1 Connected Together
A2 To be Connected to Line
F2 To be Connected to Starting Box
FIG. 1
A To be Connected to Line
F To be Connected to Starting Box
FIG. 2
F and A2 To be Connected Together
A1 To be Connected to Line
F2 To be Connected to Field Terminal on Starter
A2 To Armature Terminal on Starter
FIG. 3
L To be Connected to Line
A To be Connected to Armature Terminal of Starter
F To be Connected to Field Terminal of Starter
FIG. 4
SF2 To be Connected to A1
A2 To be Connected to Line
SF1 To be Connected to Armature Terminal of Starter
Sh F2 To be Connected to A2
Sh F1 To be Connected to Field Terminal of Starter
FIG. 5
L To be Connected to Line
A2 and SF2 To be Connected Together
A1 To be Connected to Armature Terminal of Starter
Sh F1 To be Connected to Field Terminal of Starter
FIG. 6
Sh. F1 To be Connected to A2
A1 To be Connected to Line
SF1 To be Connected to Armature Terminal of Starter
Sh F2 To be Connected to Field Terminal of Starter
FIG. 7
Sh. F1 To be Connected Field Terminal of Starter
A1 To be Connected to Armature Terminal of Starter
L To be Connected to Line
FIG. 8
To Field Terminal on Starter
To Armature Terminal on Starter
FIG. 9
To Armature Terminal on Starter
To Field Terminal on Starter
FIG. 10
To Field Terminal on Starter
To Armature Terminal on Starter
FIG. 11
To Line
Switch
Fuses
Lamp
FIG. 12
To Line
Switch
Fuses
Lamp
FIG. 13
To Line
Switch
Fuses
Lamp
FIG. 14

External leads as indicative of type of motor.

terminal *A*, the lamp will again light. This will indicate the other armature terminal of the machine.

After the armature terminals have been located, connect the test circuit to terminals *F* and F_1, as shown by the dotted lines. If the lamp lights dimly the machine is shunt wound, and if brightly, the machine is serieswound; also, if it is shunt wound a severe spark will occur at the field terminal when the test circuit is broken. This will not be the case if the motor is series wound.

There is another way that the machine can be tested to find if it is shunt or series wound, in case a test lamp is not available. First, connect the field and armature in series, as shown in Fig. 2, and the remaining terminals to the line. If the motor is series wound it will start up with a strong effort and will soon reach a very high speed if not loaded. On the other hand, if it is shunt wound, if it starts at all, it will be with a weak effort and at a very slow speed. In most cases, it will not start at all, but if the armature is turned by hand it will be found to have a tendency to turn in one direction, and when the line switch is open, there will be a severe arc.

In case the machine is compound wound and connected as in Fig. 7, there would be four terminals appearing on the outside, as in Figs. 1 and 3, so along with making the test as described above it will be necessary to see that one of the armature terminals does not connect direct to the field coils. The terminals of a compound motor with its leads brought out, as in Fig. 5, may be located as follows:

First, test for the armature terminals as described in connection with Fig. 12; then connect one side of the test circuit to one of the four remaining terminals, such as *F* in Fig. 13, and then with the other test terminal make connections first on one and then on another of the three terminals, such as F_1, until the lamp lights. The test lamp is connected to the field winding shown in fine lines which indicates it is the shunt, and in that case the lamp will burn dimly, due to the high resistance of the field coils, and when the circuit is broken, a severe arc will occur as described for the shunt motor. This leaves two remaining terminals to be tested. When the lamp is connected to them it will burn brightly for the series field always has a low resistance. This is also true of the armature.

When one side of the armature and one shunt-field lead are connected to the same terminal, as in Fig. 4, and it cannot be seen just what terminals the leads run to, a test can be made as follows: First, disconnect one armature lead at the brushes or raise the brushes from the commutator. In Fig. 14, one armature lead is shown disconnected from the brushes. Connect one side of the test circuit to this armature lead. With the other side of the test circuit, test the outside terminals until the lamp lights. It will burn brightly if connected to terminal *L*, whereas, if the test circuit is connected to terminal *F* instead of *L*, it will burn dimly, for now the field is in circuit. When the lamp burns brightly, it indicates that the armature lead goes direct to terminal *L*, and when dimly that the field is connected to *L* and *F*. If one side of the test circuit is connected to the brushes and the other to terminal *A*, it will again burn brightly, but if one test wire is allowed to remain on the brushes and the other is placed on *F* or *L*, the lamp will not burn; this will indicate that the armature lead alone connects to *A*.

In a great many cases the manufacturers mark the terminals, and in most cases these marks can be relied upon as being correct when the machine comes from the factory, but if the machine is repaired it is not always in reliable and careful hands, and in some cases these markings are mixed up, consequently, the safest and surest method is to test the machine before it is connected up.

The Prismatic Astrolabe*

By David Rines, United States Naval Observatory Washington, D. C.

THE method of equal altitudes for the astronomic determination of the observer's position upon the earth's surface leads to results of such surprising accuracy that it has been termed incontestably superior to any other. As the name suggests, this method calls for the observation of celestial bodies in various portions of the heavens, but always at the same altitude, the observation consisting merely in noting the time when this altitude is attained.

As the altitude itself is entirely eliminated from the results in the course of the computation, its exact value, affected by constant errors of graduation, eccentricity, level, collimation, azimuth, flexure, etc., is of no consequence, provided only that it is the same for all stars observed. The local time and the latitude thus obtained, free from systematic error due to these sources, are remarkably precise.

The method itself was introduced by Gauss, who first pointed out its advantages a century ago. Employing a sextant and artificial horizon, this illustrious mathematician, even with such crude apparatus, and with only three stars, obtained a value for latitude which excited wonder. After Gauss, others experimented with the sextant; but only the brighter stars can be observed with this little instrument. Very few of these can be found at a given altitude within a reasonably short period of time, and the small magnification necessarily employed to permit keeping the star in the field of view is not conducive to sharp observation. Sextant work cannot be relied upon for work of extreme precision.

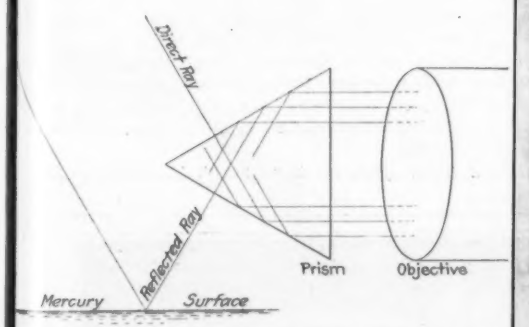


Fig. 1.—Elements of the prismatic astrolabe.

Experiments were accordingly made with theodolites and other instruments rotatable around a stable vertical axis, and very good results were obtained by careful manipulation; but the artificial horizon was here replaced by some device like the spirit level, and this reintroduced the bugbear of systematic error. The method of equal altitudes, therefore, despite its advantages, though employed extensively at sea, was long neglected on land.

Recently, the French took hold of the problem, and, in their ingenious way solved it by inventing and improving a new instrument, "l' astrolabe à prisme," "the astrolabe with a prism," or the prismatic astrolabe. Of this, there are several forms, but the principle in all is the same. Like the sextant, the astrolabe involves the use of an artificial horizon, but it replaces the two separate sextant mirrors by a single equilateral glass prism. The prism is mounted, edges horizontal, with rear face vertical, in front of the object glass of a horizontal telescope rotatable on a vertical axis in a horizontal plane, and the whole—prism, telescope, mercury basin and other appliances—is supported on a tripod like a theodolite.

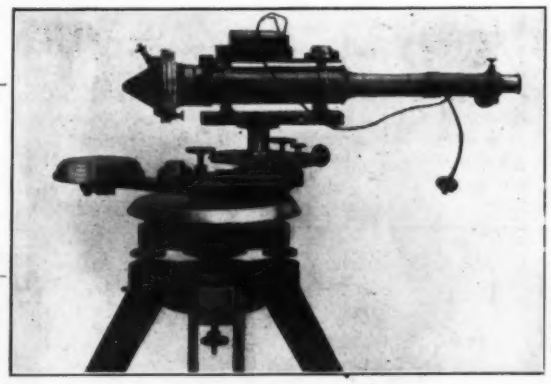


Fig. 2.—Prismatic astrolabe for determining latitude and time by the method of equal altitudes.

One face of the prism receives light directly from the star, another from the star's image reflected in the mercury, and the two light rays, after interval reflection, pass through the rear face of the prism to the object glass. Stars are thus observed at a constant altitude of 60 degrees.

For time determination, observations are made in the neighborhood of the prime vertical, where the altitude changes most rapidly; for latitude, near the meridian. As it is easily possible without field illumination to observe stars as faint as the seventh magnitude, a skillful observer may secure thirty to forty stars in less than an hour, and this number is sufficient to give very good values for both time and latitude.

An interesting feature of the astrolabe is that, unlike other instruments, the results obtained, if the prism be well constructed and by employing reasonable care, are almost entirely independent of errors due to maladjustment. The telescope should be perfectly horizontal; so also should the prism edges; and the rear face of the prism should be vertical. If, however, the prism edges, for example, are not horizontal, the skilled observer will recognize this fact when he perceives the motion of the star in the field of view and a slight touch of a screw eliminates the inconvenience; indeed, this adjustment is generally effected on every star.

The one important adjustment—and even that is not absolutely essential—is the perpendicularity of the rear face of the prism to the axis of the telescope, which is easily effected by aid of a simple auxiliary device. If the adjustments are not perfect, the only error involved is in the observed altitude which, instead of being 60 degrees, may be some larger or smaller quantity; but if care is taken to make all observations in the same portion of the field, and in the same way, this quantity will be the same in all positions of the instrument. All stars will be observed at the same altitude, and the resulting latitude and local time will be unaffected. With the newer type of prismatic astrolabe, permitting temporary field illumination, this condition is easily fulfilled.

There are no instrumental constants to be determined, and consequently there are no systematic errors introduced by such constants. There are no circle measures, with the danger of reading and recording them incorrectly. There are no errors of nadir, pointing, thread inclination, pivots, etc., such as affect observations with other instruments. In fact, nearly all constant errors, affecting all observations alike, are eliminated. There is danger of systematic error introduced by the personal equation in noting the times of observation, but almost all other errors are of the accidental class, and may be eliminated by increasing sufficiently the number of observed stars.

The manipulation of the instrument is simple, rapid and easy. Guided by a previously prepared list of stars containing approximate times and azimuths, the observer first sets the telescope in azimuth, then seating himself at the eye end, watches the star and its reflected image enter the field of view from opposite directions. He touches a screw, perhaps, to cause the images to change slightly their relative positions, or to bring their vertical line nearer the center of the field. As the images draw closer in their approach toward each other, he concentrates his attention and at the moment of coincidence makes a record of the time, either by the eye and ear method, or by the chronograph and key. In this record is comprised the whole observation.

The computations both preliminary to and succeeding the observations are long and tedious. An hour's observing list requires many hours of preparation and subsequent computation. The labor of preparing the observing list may be considerably shortened by tables and other aids; and the final computations, too, may be made more easy by tables and graphic processes. The fact, nevertheless, remains that the computations are time consuming. In view of the high precision attainable, this objection should carry but little weight, particularly when it is remembered that the computations may be made at one's leisure, long after the observations have been completed.

The instrument is comparatively inexpensive, it is light and portable, and requires no previously established stable foundation, but may be set up in a few minutes. These considerations should recommend it particularly to geographers, explorers, surveyors and other travelers who seek accuracy, yet do not wish to encumber themselves with the comparatively heavy portable transit and accompanying chronograph. For the very finest kinds of longitude work, however, owing to the personal equation, the astrolabe should be looked upon with suspicion. Yet it should be remarked that it has been used side by side with portable astronomic transits of the best known types, and the results obtained by the two different kinds of instrument have been wonderfully close.

The prismatic astrolabe has been employed by the French on boundary and other survey work in their colonies, in the measurement of a meridian arc in Ecuador, and more recently in important wireless longitude determination. It was used in the spring of 1913 in the preliminary operations attending the determination of the difference of longitude between Washington and Paris.

The astrolabe may be employed for absolute longitudes by observing equal altitudes of stars and of the moon. It can advantageously replace the portable transit in much of the longitude work now carried on in this country, and would result in considerable saving. Among other applications, it may be employed at fixed observatories to determine star positions. Our astronomers and engineers should give it a trial.

For an exhaustive discussion, the reader is recommended to A. Claude et L. Ducncourt, "Description et Usage de L' Astrolabe à Prisme."

* From *Engineering News.*

The Effect of Water Pressure Upon the Form of Fishes

A Study of Evolution of Form Resulting from Conditions of Life and Habits

An interesting account is given in *La Science et la Vie* of the effect of water upon the form of fishes. The article is written by Frédéric Houssay, professor at the Sorbonne. In his hands comparative anatomy has developed into dynamic morphology, which seeks to explain the characteristics of animal forms as the direct or indirect reactions from the action of the surrounding world.

In the article on the shaping of fish by the pressure of water, Prof. Houssay tells us that naturalists for a long time have agreed in admitting evolution in living beings. Nearly all scientists at the present moment find no difficulty in believing that the infinite variety of animal forms, now existing or extinct in the course of geologic ages, is the result of incessant changes carried on without intermission. These changes take place with a slowness or an infrequency which prevents us from perceiving them readily in our short life. One can, though, very easily imagine that these modifications, suspected or recognized on a small scale, produce in the course of time very important results. Difficulties commence and arguments begin when it is sought to specify how such an evolution takes place.

A great many scientists believe that the ability to change is a quality innate in all living beings, an essential characteristic, and that evolution is to some degree no more than the exercise of this faculty, than the realization of this inner power. Others who are still in the minority, but whose numbers are growing and among whom our author must be counted, are unable to believe that a living being is capable of modifying itself when there is no change around it. They consider the changes in creatures as the reproduction or the reflection of the changes that take place near them, and that these surrounding changes are themselves united by an unbroken and gradual connection with all that takes place everywhere in the infinite world.

It is plain that one cannot do everything at once and that it is necessary to attack this problem a section at a time. Thus, our author has been led to try to solve the definite question of the form of fishes, and to inquire into the role which the surrounding medium, that is the water, has been able to play in the construction of this form.

As, in the present discussion, the question will always be of water in motion, and even in vortex motion, we must regard this fluid, in the matter to be elaborated, as both elastic and oscillating.

Although it looks simple this question of the form of fishes is one of the most difficult, and our scientist does not claim, in the course of a short article, to go into it in detail with the exactness he showed in the work already mentioned on the "Form, Strength, and Stability of Fish." He merely tries to indicate the succession of ideas and the course of the demonstration.

First of all, it is necessary to agree on the fish form which shows variation. Leaving aside all those which are too long or too flat, such as the eel, the ray, the sole, plaice, dabs, and the turbot, let us take simply the actual swimmers in open water, for example, the shark, trout, salmon, the maigre, red mullet, sardine, herring, mackerel, and even also the carp and the dolphin, which are already a little flattened at the sides, but not yet too much.

In order to understand how water has been able to mold the fish, it is necessary first to grasp the idea that all creatures are plastic, that is to say, can suffer deformation under pressure, exactly like potter's clay under the finger, less quickly, it is true, but as certainly and as completely if the time required is given.

"Suppose we explain what is meant," says our author, "by an example chosen among thousands. Everyone knows that a child that carries itself badly becomes mis-shapen by allowing his weight to exercise pressure unsymmetrically. On the other hand, the deformity can be rectified by an appropriate compression. If then in several years light pressure can modify a body under our eyes, what cannot be expected of far greater forces which have been working without cessation for ages upon ages?

"What then is this far greater force which we allege? It is the resistance of water; it is an enormous force. The power of this force can be very simply tested by plunging the arm in water and trying to move it there rapidly. It will soon be seen that the resistance varies considerably according as the hand is placed flatwise or edgewise. The water will even turn the hand edgewise, if the muscles of the forearm are not stiffened and the hand is left limp in concentrating all the force in the upper arm and shoulder in order to obtain the movement. It is known, moreover, that this resistance is proportional to the square of the velocity of displacement.

Having at our disposal the plastic living being, and the great molding force, it is further necessary to define the conditions in which the latter acts upon the former. The two essential necessary and proper qualities for selecting a fish with a plastic frame are that he should have the power of rapid movement, and that he should have the same density as the water. All well-made fish weigh, in equal bulk, it may be said just as much as water, hardly more, hardly less. That removes from our investigation all vertical force drawing toward the bottom or the surface.

If one change is introduced everything changes. Thus, the deformed or badly shaped fish, those too long or too short, are decidedly heavier than the others or the water. On the other hand, some, as the mola or moonfish, are decidedly lighter, and become mis-shapen at the surface, while the former grow mis-shapen at the bottom of the water.

Creatures which might be still heavier, and also less rapid in movement, would not be formed at all in the shape of fish, but in that of annelida and crustacea. Creatures heavier still, as well as more sluggish, would become creeping mollusks; and others, absolutely heavy, which do not move at all, attach themselves to the algae, to the rocks, or bury themselves in the mud, and are thus molded.

This is the reason why the resistance of water, which is always the same, does not always produce the same effect, because it is not always exercised in the same way; and why all aquatic existences, equally plastic, but of various weight and rapidity of movement, are not alike.

"This much being clearly understood, let us see by experiment how water can model a body that is plastic, quick in movement, and of uniform density, and which weighs just as much as an equal volume of water.

"And first of all, how should one experiment to put himself in the same conditions as those under which a fish swims? The latter gives a short stroke of its tail to the right and left, and then moves ahead very straight and rigid without making any propelling movement, but only little stabilizing movements with its fins. The first period lasts several tenths of a second, the second, the straight ahead movement, lasts 5 or 6 seconds. It may then be said that this is the condition under which the fish encounters the resistance of the water, and in which the shaping is effected. It is, therefore, possible to reproduce this state in which the fish is not mis-shapen by himself or actively, but submits passively to the pressure of the fluid. To reproduce this it suffices to draw through the water the experimental body, for instance, by a line passing over two pulleys, at the end of which a weight, which falls, is suspended, and it will also be possible to vary the velocity of movement by varying the weight.

"A first molding of the form of the fish had been recognized before me, and I add nothing to it. It is that shaping by which the forward part grows heavier and enlarges, while, on the other hand, the rear part tapers down. A second molding of the form, that I have discovered, and which consists of repeated inversions, ought to be superposed upon the former, but for the sake of studying it alone it is necessary to separate the one from the other.

"In order to have a body, a model which will be plastic, I take a pliable rubber bag about 20 centimeters long and 4 centimeters wide; and in order to have it equal in mass to the water I fill it with a mixture which I make of oil, vaseline, and white lead, which weighs just as much as water, bulk for bulk. In order to give it velocity I attach it in the water to a line which the fall of a weight is to carry along. Nothing further needs to be done but to watch what takes place when the speed is increased, the bag being closed by simply pressing its opening between two well-united adhesive binders."

At a slight speed the bag, smooth in shape at the

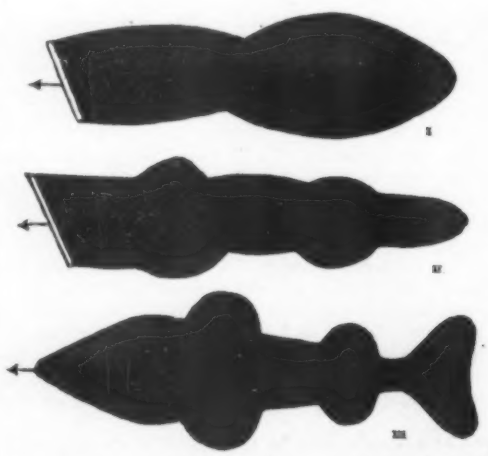


Fig. 1.—Shapes produced by the resistance of water.

To obtain a plastic form as dense as water, a rubber bag is filled with a mixture of oil, vaseline, and white lead. This bag, towed through the water, at a certain speed, assumes the form *I* of two inverted sections. At an increased speed it shows form *II*, five opposing sections. The combination, *III*, of these forms with a shape molded in advance, produces a result decidedly analogous to that of a fish; the fish form differs from this model by the absence of the lower front fin.

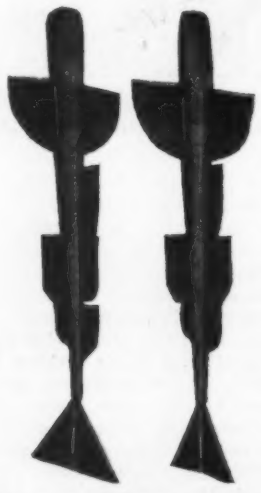


Fig. 2.—These two models of long form have aluminium fins, the front edges of which are turned over and threaded on a steel pin. The rear part of these fins is attached by a rubber band to the wooden body. The fins produce stability by oscillating under the eddying of the water.

Fig. 4.—Cone-shaped model with vanes at rear end.

A conical model equipped with vanes at the rear end, like those of dirigible balloons, is only stable at low speeds. In this regard, this device is very inferior to fins.

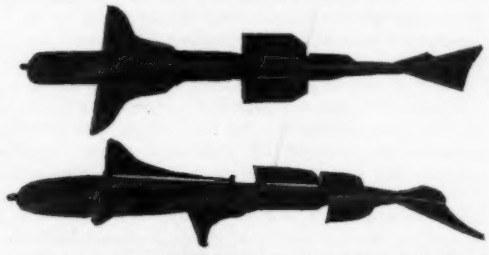


Fig. 3.—Scythe-shaped fins increase stability.

Above, long model of fish in which the pectoral fins only have been hollowed out like a scythe to secure stability at certain speeds. Below, a squaliform model, ballasted dorsally, in which this arrangement has been reproduced, first for the pectorals, then for the first dorsals, and finally for the caudal fin, after which it remains stable when the speed increases.

start, remains unchanged; the transverse waves merely flowing over it, or else turning on its axis. At a sufficient velocity it plainly shows two opposing surfaces, that is, the forward part remains smooth and horizontal, while the rear becomes flattened vertically. If the velocity be further increased, the number of inversions increases, and there can be counted three, five, seven, or more of them, which are alternately horizontal and vertical, the body being inverted in three, five, or seven sections.

The vortices of water fly backward to make room for a moving object which penetrates it. In the presence of the obstacle which the bag opposing itself to their flight forms, they assume an aspect which is repeated in a certain rhythm, it is what is called an oscillation. The oscillation of the water molds the pliable bag which it holds fast, and it is the bag which proves it to us, for the latter is visible and the oscillation is not, Fig. 1—I. It is an evident application of one of the most beautiful theorems of physics discovered by Lord Kelvin on the transformation of a vortex into oscillation in the presence of an obstacle.

However, let us lay aside for a moment these views of advanced theory, and let us place this inverted shape, which we have just examined by itself, upon the one which shows a form with a large and a small end. Let us form upon the body, upon the hull, a shape of two inverted surfaces, flattening the front part (the large end) on top and bottom, and the rear (little end) on the sides (Fig. 1—II). It is the evidence of what has taken place when the velocity was not yet very great. Let us form further on the two preceding models six inverted sections (Fig. 1—III); it is the evidence of what took place when the speed had somewhat increased. But the size of the body has not been affected as to its mass by this last molding; the latter has merely drawn out the surface in sections alternately horizontal and vertical.

The cut (Fig. 1) shows that an object successively shaped in this manner would have a curious resemblance to a typical fish with its inverted body, and its fins alternately horizontal and vertical. But as compared with a fish it would have one fin too many, the lower forward one. In fact, the fish would have assumed this form with scrupulous exactness if it had been homogeneous, that is, if it had the same density in all parts of its body. Such, though, is not the fact, the back is the heaviest part, and it is because of this that dead or tired fish turn up the belly. It is also for this reason that our model does not quite resemble a fish. However, we seem to have obtained the solution more or less in principle; all that is now necessary is to retouch it in certain points. This will be done little by little, and these alterations will also be full of interest.

Before leaving this preliminary survey, let us dwell a little further on one fact. We have said that the multiple inversion was caused by the changing of the whirling of the water into oscillations, and this has reference to the arrangement of the fins with which we have compared it. Inversely, now that the fins exist on the fish, they direct the vortices which fly backward in proportion as the fish advances. "To prove this," says our author, "I took fish of various kinds

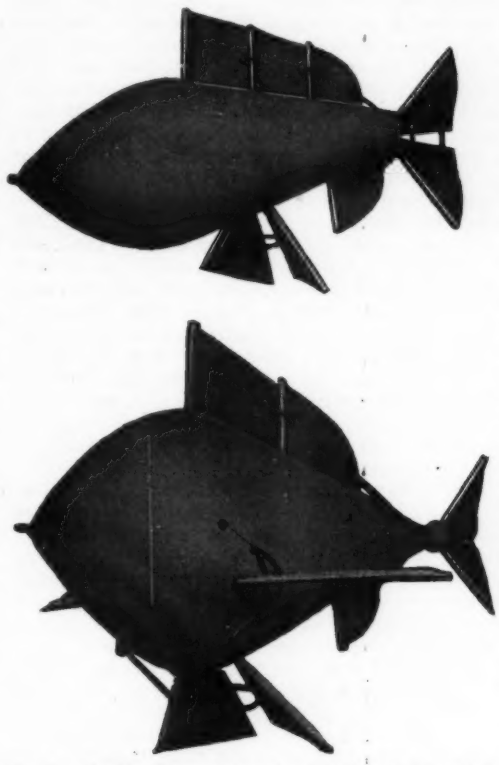


Fig. 5.—Models for studying the stability of flat-sided fish. Upper figure model of a carp; lower a dolphin.

and passed into their skins silk threads held by a knot and floating freely in the water. When the fish sculls gently the silk threads undulate to its right and left; when, after a good stroke of the tail, it moves quickly forward the silk threads roll themselves around its body, passing between all the fins and outlining between them all two spirals or two screws with inverted thread, characteristic of vortices."

In order to examine the question more closely, it is now necessary to look at it from another side. If it is really true that the water has molded the fish, it must have made of it a shape of minimum resistance, for, so far as this result had not already been attained the water took hold to mold and efface, and its action is carried on until it has the least influence possible, corresponding to a minimum of resistance. An attempt can be made to prove this.

"I took," continues our investigator in discussing the subject, "six models of the same length and diameter, and having the following forms: form of a fish; a cone with apex to the rear; a cone with apex to the front; a double-pointed spindle; and a spindle with its ends flattened in mutually perpendicular planes, and a body bounded by a discontinuous surface of two sections joined at the middle. Each model was built in three lengths: small, medium, and long. In all eighteen models were tested at speeds increasing from 50 centimeters to 7 meters 50 centimeters a second. The models were drawn with a line operated by a falling weight, and were carefully timed by a chronometer. They gave eighteen curves of motion, which have been carefully compared, and the result showed the fish was by no means the best. It only came in third, the first place being held by the cone with the large end forward. Moreover, it was impossible to determine which of the forms, short, medium, or long, was the best.

The result as regards a fish-body is decidedly important. First of all, from a practical point of view, it condemns in advance any attempt to make the envelope of a balloon, or the hull of a submarine or of a torpedo, a direct and unchanged copy of the body of a fish, even of a swift one. The imitation should be more complete and exact. Then, from the theoretical point of view, this result teaches us that to conduct our investigation successfully the question to be considered is not one of taking a part of the fish while neglecting the rest; for instance, the body, while forgetting the fins, but that it is necessary to take the whole, body and fins, since in fact the water has molded all and did not stop so long as there was anything to do.

Through the knowledge of these facts and through reflection the writer was led from the problem of velocity to that of stability, which is by no means less important. All these plain forms advanced at the end of their line with complicated oscillations which fish never make; they are absolutely stable. He then thought that his models would also become stable if he succeeded in imitating on them the play of the fins. The artificial fins were simply small thin plates of aluminium pivoted on a steel pin and attached to the model at their rear side by means of rubber elastic.

Fins were fitted on the three most interesting models in the three lengths, that is, on the model with the dis-

Fig. 6.—The thresher, one of the fastest swimmers of the shark family.

Fig. 7.—The ray.

While normal fish have almost the same density as water, rays are decidedly heavier. Their condition in water is that of birds in the air. The large pectoral fins, spread in the shape of wings, beat the water to give at the same time both support and forward movement. The tail, the propelling organ in other fish, is here only a "reminiscent" organ; it regresses, and drags useless in the water which tapers it down.

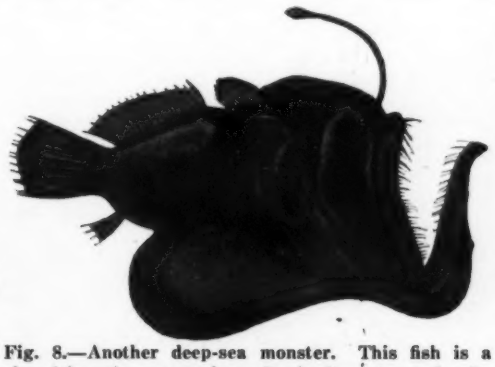


Fig. 8.—Another deep-sea monster. This fish is a sluggish swimmer, and awaits in its retreat for its prey, some weaker fish, to swim by, when it opens its huge jaws, and its victim is drawn in by the strong current induced.

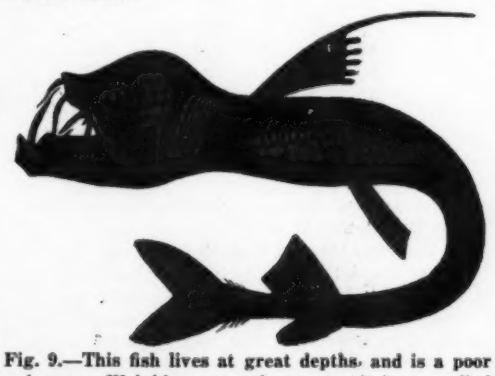


Fig. 9.—This fish lives at great depths, and is a poor swimmer. Weighing more than water it is compelled to keep near the bottom, where it lies in wait for its prey, being unable to chase it.

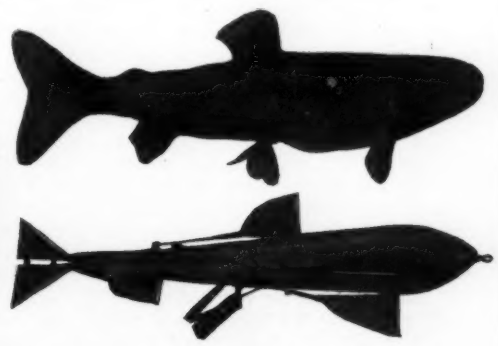


Fig. 10.—Trout and artificial model with one dorsal fin. This shape, weighted dorsally, is adapted to great speeds, but its stability is uncertain, as it requires a definite tension of each fin at each speed. In this model it was proved that the paired fins, widely extended at low speeds, become progressively relaxed as the velocity increases.

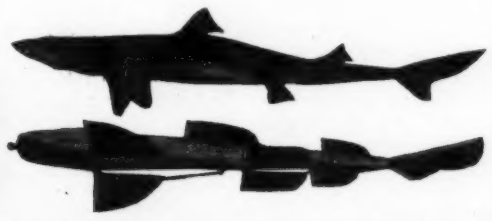


Fig. 11.—Neutral shark and squaliform model. Like the natural fish, the model has the back heavier than the belly. Neither, however, capsizes in swimming owing to the suitable tension of the fins, which always remain spread, and to the form of the tail, which is heterocercal, that is, having two unequal lobes.

continuous surfaces, on the fish, and on the cone with the large end forward. Thanks to the fins, which oscillated under the eddying of the water, these nine models became entirely stable, and moved absolutely straight ahead at nearly every velocity. Only at certain velocities was there rotation around the axis, a simple irregularity which he did not know how to correct until later, as he tells us further on.

The results of this new investigation were the following: In each form of model it is always the shortest length which is the best; then comes the medium length; and lastly, the long one. On the other hand, among the forms of the same length, the classing is always the following: 1, fish; 2, cone; 3, model with the mutually perpendicular planes.

So when the fish is taken as a whole, and what nature has produced is imitated down to the details the speediest and most stable form is obtained. The cone having lost the first place, it may be objected that stabilization by fins does not suit it, and that it would be better, for instance, to give it a caudal vaning, like the feathering at the end of an arrow, such as is used for balloons. Our author tried this experiment. The cone with the vaned tail (Fig. 4), did not travel well except at low speeds, after which it turned constantly and violently around its axis. The caudal vaning is, therefore, inferior to fins.

Will we be able to develop our aerial and aquatic machines so far as to make use of a stabilizing device analogous to fins, which will cut and direct in vortices the eddies of the resisting medium? Monsieur Houssay is convinced that the thing is possible. The inclined planes or redans arranged under the bottom of aerial boats with screws are already a slight but evident indication of the benefit which could be obtained by it (for a further discussion of this point see *La Science et la Vie*, May, 1914, p. 204).

However, nature has many fish to show which seem to be very fair swimmers, and which are much more flattened on the side than the models examined up to now. Our author wished to study the conditions of their movement and he made two models (Fig. 5), the one, in the form of a carp, very slightly flattened, the other shaped as a dolphin, which is much more compressed. While the earlier models nearly always traveled well, except at certain speeds, he had the greatest difficulty in making these latter ones run straight. In the end, after much experimenting, he found that the rubber bands attaching the ventral fins ought to have more or less tension according to the velocity. To obtain this result he connected the rubber bands to a line attached to a screw set in the body, and by turning this screw in one direction or the other the rubber bands were stretched or relaxed.

For low speed the rubbers should be loose; while at a certain higher speed it was necessary to have considerable tension. Everything went well for some time when, all at once, the speed increasing the rubber had to be entirely slack; and after a further interval he was obliged to stretch it as previously. Consequently, two tensions are necessary, a slight one and a strong one which are successive as the speed increases. The action of fish is not at all like this. Their paired fins, which at high speeds are completely closed or suppressed along the body, are successively unfolded and stretched more and more as the speed diminishes. This difference raises a remarkable problem, of which our author soon gives the solution by showing that it depends on the position of the center of gravity.

"In examining the velocity of these last models," he states, "I found their result very inferior to that of the preceding models. We have already noticed that the extremely long models do not travel as well as the short ones; now notice that the flattened models do not travel as well as the roundish ones, and this is why, at the beginning, I called fish which are too long or too flat mis-shapen or ill-made.

"Still, the study of these models has taught us something very curious and very important: this is the possibility of securing stability by stretching or relaxing the attachment of the fins. If I had known this when investigating my rounded models I might have been able to prevent their turning at the few velocities in which this phenomenon appeared. I, therefore, took them once more; and fastened the end of the rubber tension bands to screws which I could tighten and relax.

"By stretching the rubbers very slightly I was easily able to suppress the rotation in the short fish-model. I did not succeed in doing this in the longer fish, excepting at tensions greater than a natural fish would have been able to produce with his muscles. It then occurred to me to hollow out the pectoral fins in the shape of a scythe, and when this was done a very slight tension sufficed. This new result was very useful to me in assuring the stability of more complicated models at increasing velocities."

Excepting the short cone, which was always stabilized by its fins, it was not possible by any means to suppress the rotation around the axis in the cones of medium and long lengths. This indicates a further superiority in the keel-fish which, quicker in movement, can be easily stabilized under any conditions. At this stage the problem seemed to be almost solved; however, there were great and persistent difficulties. The models, which we have just studied, do they agree satisfactorily with the three qualities which we know are essential to obtain a fish: swiftness, plasticity, equal density, and how do they agree with these?

As regards swiftness, nothing is changed; they are, under the conditions of the first experiments, comparable to the swimming straight ahead of fish. The models are plastic and can be changed in shape, but the plasticity is localized in the oscillating and elastic fins. Each of them, therefore, corresponds to a given fish at a given velocity, the body of which fish, at a minimum of resistance, is no longer molded beyond a certain shaping down. The diversity of forms studied represents the variation of the shaping down. Lastly, the models were made of equal density with the water, and for this, as they were of wood, and to insure their proper floating, they were ballasted just enough to keep them under water without sinking. This ballast was put in the belly and naturally it contributed its share to the stability. This condition is not at all that of the fish, in which the back is heavier than the belly. The ballast should have been on the back, but in such case how could the models be made to maintain its proper position? This is the real pith of the matter, but how to reach it.

"The question was very difficult," says our author. "Let us, first of all, recapitulate the differences which persist between our models and natural fish: First, ventral ballast instead of dorsal ballast; second, the fins in pairs, pectoral, and ventral, are on the lateral line, that is, at the center of the side instead of being at the ventral edge; third, play of the fins, tension and relaxation, not in agreement with that of fish.

"I, therefore, remade my models by putting the ballast toward the back, and in such manner that they capsize immediately. I lowered the pairs of fins to the ventral edge of the body, but I left the tail as it was before, that is, with two equal lobes, homocercal, as zoologists say.

"I had hundreds of setbacks; my model did not capsize once for all, as might have been feared, but it rotated constantly on its axis. It then occurred to me to make the tail heterocercal, that is, with a large upper lobe and a small lower lobe. This was what was needed, nothing else, and my failures were transformed into definite successes. My model had become all at once equal to a natural shark, and moved along exactly like a shark."

The correct action of this moving body demanded very exact tensions of the fins. The ventral fins needed the same tension for all velocities, and there were no difficulties on this account; but the pectoral fins had to be regulated exactly for each velocity. At low velocities this regulation could be easily made on the model with rounded fins. In proportion as the speed increased the scientist was obliged, after numerous experiments, to scoop out the pectoral fins in the shape of a scythe, then to hollow in the same way the first dorsal fin, then lastly the upper lobe of the caudal fin. He thus obtained the whole series of natural forms of the squalidæ with the exact conditions of speed to which each one corresponded.

The sciences of comparative anatomy and palæontology have taught us that this squaliform shape is the most primitive and the most ancient, and our author succeeded in reproducing it exactly, with the exact play of its fins more or less stretched, but always open and spread out, never closed or suppressed.

He also desired to reproduce artificially the conditions in which those fish exist which have appeared more recently in the waters on the surface of the globe, and he remade his models of carp, of dolphin, and of roundish fish with two dorsal fins, which are very good for low velocities, and the models of roundish fish with a single dorsal fin, the best shape for great velocities. All these he remade with a dorsal ballast and with fins lowered to the ventral edge.

The problem constantly grew more difficult, for it was necessary to find a correct tension for each velocity in these models, not merely for the pectorals, but also for the ventral fins, and at times for the first dorsal. After repeated experiments he always reached the goal, and, taken altogether, the action of these various fins can be summed up thus: extreme tension of the pectoral and ventral fins for low velocities, progressive relaxation proportioned to the increase of speed, complete suppression of movement at very great velocities. This agrees exactly with the actions of natural fish, and we have reached this precise result by having recourse again to the condition of the dorsal center of gravity.

"Now that we have exactly reproduced all the principal kinds of fish by determining solely the conditions of the least resistance and of stability in the water," says the author in his summing up, "we can stop, for it is impossible for me to expound in a short article the investigations I have made as regards the shape and position of the mid-frame; those relative to the conditions that have changed the heterocercal tail of ancient fish into the homocercal tail of more recent fish; relative to the displacement of the ventral line toward the head in proportion as the vertebral column becomes more and more bony in the course of geologic ages; relative to the particular transformation of the fins and to the deformations of the body in cases where speed of movement is lost; relative to the improvement in shape of fish formerly slow, which have become very swift, as the cod and mackerel, the fins of which have been recut in a very special manner. I merely mention these details selected from many others, to show that these new methods of zoological investigation can, if we start from a well-defined point and have a clear conception of what is needed, lead to the explanation of all the combinations of parts and of all the details."

In conclusion let us take a hasty view of the indications from which engineers might profit in improving the speed and, above all, the stability of submarines, submersibles, torpedoes, dirigible balloons, etc., in those cases where the latter have a weak power of ascension, and so far as they can be considered as evidently equal in density to the air. In the first place, as has already been said, it is useless to limit oneself to copying body for body, the result would be inferior to that which is already in common use. What is necessary is, to reach the point of placing oscillating fins on the keels under the simplest conditions.

The fact that fish draw in their paired fins at very great speeds is not an opposing indication: first, because they always keep open their single fins, and further, because they cannot close the paired fins excepting at velocities which, on account of human limitations, large engines, such as balloons and submarines, can never equal, and, lastly, because this closing is only obtained by aid of small exact changes of form which result from the dorsal position of the center of gravity.

Now it would be absurd to desire to imitate this condition which, for a slight improvement in speed, would give an extremely precarious stability. No one dreams, for instance, of putting the car above the balloon. Therefore, neither is it necessary to imitate those conditions which are connected with this.

If we leave the center of gravity fairly low, which is certainly the best thing to do, we return, not to the exact condition of fish, which it is well to avoid copying too servilely, but to the approximate conditions of our author's first models ballasted ventrally. The paired fins ought in this case to be placed in the center of the side and not at the ventral edge. Above all, an important point in practice, they can be stretched once for all for nearly all velocities, and it would not be necessary to touch them again except to change the direction. Moreover, the direction could be easily obtained without touching them by preserving the present rudders, which would serve nothing but this purpose, and, above all, would correct the lurchings, the rollings and pitchings being totally suppressed.

For the rare critical speeds, where the ordinary tension of the fins would not be sufficient, if such should be attained, it would be very simple to change the tension since there could be but two tensions possible with no intermediary between them. For these velocities it would suffice to bend the attaching spring (replacing the rubber) an amount known in advance, and which could be found without awkward fumbling.

It is clearly evident that all our heavily ballasted engines can move without stabilizing and oscillating fins; the proof is that they do it. But with these fins and under the conditions mentioned they would have an indestructible stability, and could advance straight ahead with all the speed that the powerful motors of the present day would give them. Besides, there would be nothing to prevent putting of the car sufficiently far from the envelope of a balloon to avoid explosions. It would suffice to make the car a second fish sailing in company with the former and below it. Our author is convinced that under these conditions of absolute stability the velocity could be increased to a considerable degree.

Casino at Interlaken

A SUCCESSFUL reinforced concrete construction is the new Casino of Interlaken, and this handsome building abundantly proves that this method does not exclude great architectural ornament. It is constructed on the Hennebique system, and has a main hall with stage at one end and seating room for 600 persons, also other accommodations in the way of restaurant, etc. The hall has a roof of 42 feet width made up of reinforced concrete cross-members to which is suspended a reinforced plaster vaulting, with appropriate relief ornamentation.

Ideals in City Planning*

Improvement and Operation of Cities a Work for Trained Experts

By Harrington Emerson

Two years ago I was in Tacoma, which has naturally one of the beautiful locations in the world. The glory of Tacoma is its Point Defiance Park, high above and surrounded on three sides by the wonderful waters of Puget Sound. At flowing or ebbing tide the waters rush swirling with a power that suggests the rapids of Niagara. Trees several centuries old grow in the park, gigantic cedars and fir and hemlock. Yet I heard two citizens of Tacoma advocating the donation of the wonderful park to the United States as grounds for a penitentiary. "We don't care for old trees and fine views," said one, "we want to sell tobacco to the soldier guards." Happily this desecration was not permitted.

Real beauty costs little. The most beautiful things in all the universe are absolutely free, the stars, the color of the sunset clouds, the hoar-frost on the trees, the breaking of waves on a shore, the budding of the trees and the blooming of the flowers in spring; and so with the cities, the most beautiful places I know in the world have not been made so by lavish expense but by intelligent care. On the other hand, the value of beauty is so great that men and women are willing to spend immense sums for the gain.

Let us pass on from beauty to health.

Without vouching for their accuracy, I quote the following list from the Census Bureau Report for 1911:

MORTALITY STATISTICS.	Per 1,000.
Seattle	8.8
Cleveland	13.8
San Francisco	15.2
Denver	15.5
Washington	18.7
Chicago	14.5
Baltimore	18.4
Boston	17.1
Los Angeles	14.5
St. Paul	10.9
Duluth	11.7
Kansas City	15.4
St. Louis	15.4
Buffalo	14.5
New York	15.2
Cincinnati	16.5
Philadelphia	16.6
Pittsburgh	14.9
Milwaukee	11.9

There is the city of Seattle whose death rate is only 18 or 36 per cent better than Cleveland. There will be the natural instinct to make excuses, to assume that Seattle is more favorably located, to deny to the intelligence and conscious effort this wonderful record of Seattle. Some will maintain that Seattle, being further north and on salt water, ought to have a better record. Let us see whether it is location or intelligence. London, England, is further north than Seattle, is on salt water and has a similar climate to Seattle, but in 1736 the births in London were 16,491, the deaths 27,581.

Seattle is a younger city than Cleveland, there are fewer old people, more inhabitants in the prime of life, therefore the low death rate. This is granted, but the real test comes when we check the deaths of children under five years old. Seattle's rate is the lowest in the world. The 1911 Census Bureau report gives Cleveland's deaths under five years of age as 31.3 per cent of the total, and Seattle's as 18.4 per cent of the total.

Forty years ago, in Munich, Bavaria, the death rate approached 40 per cent of births for children under one year of age; in Seattle the record is under 10 per cent for children under five years of age. The Seattle rate in fact approaches 8 per cent.[1] In this matter of life and death I hold up Seattle as an example of what can be attained by knowledge, faith, courage and power.

A city consists of people and also of buildings. The word health, in a large sense, applies to the conservation of property from fire. How does Cleveland stand in this respect? There are good sized cities in the world whose fire loss, owing to excellent preventative measures, is only $0.04 per inhabitant per annum. Cleveland's loss is reported at $2.43[2] or 60 times greater than that of some of the Swiss cities, and this does not take into account the loss of business due to fires, nor the cost of fire departments, which are palliatives, not remedies.

In a fourteen years' residence in various European cities, I saw only three fires. We excel in the work of fire extinguishment but what we want is fire prevention, and our studies and the experience of other great world cities show that the fire loss ought to be reduced to about $0.24 per inhabitant.

The best civic virtue is intelligence. What is a man of first class intelligence and training worth compared to the average man? Why are Denmark, Norway and Sweden rich and Nicaragua, Honduras, San Salvador, Guatamala poor? Why have property values doubled in the Philippines in the last fifteen years? In our special work of human efficiency, we have in many cases found no difficulty in bringing up the average efficiency of a thousand men from 50 per cent to 100 per cent without discharging or harrying any of them.

Remember that I am not putting up any task that has not already been attained elsewhere. Human intelligence is without limit and there is always more ahead than there is behind.

The next fundamental is morality, reliability.

It is far easier to build up the morality of a city than the morality of individuals. A certain number of people are born wicked but even they are wicked only a small part of the time, and in a model city even these people would either behave, leave, or be controlled.

The next and last fundamental is industry.

If assessments both real and personal were on the same basis everywhere in the United States, they would be comparative. The average valuation per inhabitant or per voter or per adult above the age of 18 might be used. Assessed valuation is an indication of relative standing, savings bank deposits are an indication, bank clearings are an indication, the per capita amounts of internal revenue tax paid for intoxicants and tobacco are negative indications.

It is difficult to give beauty, health, intelligence, morality, industry a money value, but would it be worth one dollar a day per inhabitant to excel in all these respects? The yearly gain, for a city the size of Cleveland, would be $21,900,000 at $0.10 a day in one year, or at a dollar a day a piece it would be $219,000,000.

That you may not feel that I have overdrawn the possibilities, I shall give you the description of two communities, one British and one German.

The island of Bermuda is 700 miles from anywhere, out of the path of all steam lines except those from Halifax to the West Indies. The island has only 20 square miles of area of which 3,000 acres are under cultivation. The island has 20,000 inhabitants, two thirds colored. The island in its roads, as well as its natural scenery, is a dream of beauty, no more beautiful place in all the world. Its healthfulness is very high, its intelligence unusual, no illiteracy, its morality so great that there is practically no crime of any kind, and its industry such that it supports without poverty 1,000 people per square mile, 1½ to the acre.

Ohio has coal mines, lies between the great lakes and the Ohio River; is the great central State between the East and West, is altogether one of the best States in the whole Union; but if Ohio had the same relative population as Bermuda, it would have 40,000,000 inhabitants.

As my second example, I shall quote from *The New Statesman's* review of Frederick C. Howe's book "European Cities at Work."

"Most people know nowadays that it is to Germany—that paradox of one of the best educated, most enlightened and up-to-date peoples of the world, yet still, for the great part, under the thraldom of a semi-despotic monarch and an uncurbed squirearchy—that we must look for the most striking examples of state socialism; but Mr. Howe's book will be a revelation to most readers as to the development and progress of the German cities.

"Germany almost alone among the civilized nations sees the city as the permanent center of the civilization of the future, and Germany almost alone is building her cities to make them contribute to the happiness, health, and well-being of the people. This seems to be the primary consideration with officials and citizens.

"Writing of Dusseldorf as a typical example, Mr. Howe states that the German city aims at being a model employer. This town treats its five thousand clerks and workmen more generously than private companies, and goes beyond the requirements of the law in regard to sickness, accident, and old age insurance. It grants all workmen and employees a retiring allowance, as well as pensions for widows and orphans. The wages paid rise with the years of service, and the conditions of work are determined by municipal regulations. This city goes in for all sorts of municipal trading. The whole city has been as much planned out as a garden city as Letchworth, and is one of the finest towns in the world. The city owns a considerable portion of the land on which it stands, some 2,500 acres belonging to it, and it has set aside a special fund of over $5,000,000 as working capital with which to buy and sell real estate, while its powers of expropriation and its taxes on increment values make Mr. Lloyd George's schemes appear reactionary. The city owns the trams, gas, electricity, and water works. It operates a municipal mortgage bank, which has already advanced considerably over $5,000,000 to people of small means for the purchase of their houses. It has built houses for its own workpeople, a home for unmarried people; it has one or two municipal restaurants, carries on a wine business, a savings bank, a municipal pawnshop, also a legal aid department, where advice is furnished free. It maintains a corps of eighteen physicians to give gratuitious service to needy persons, while it has numerous municipal hospitals, infirmaries, sanatoria, and nursing homes, as well as an academy of practical medicine attached to the principal hospital. It owns and maintains a fine theater as well as a great concert hall; it supports a symphony orchestra of sixty-one players, and provides musical direction. It also maintains a fine arts gallery, a museum of natural science and history, and a zoological garden, all of these agencies being correlated with the educational system. A few years ago the city invested something over three-quarters of a million sterling in the shares of an industrial undertaking of a profitable nature identified with the city. As might be imagined, its indebtedness is large, being in the neighborhood of $30,000,000, but no less than 87.3 per cent of this is placed in industrial undertaking, and against this indebtedness the city possesses assets exceeding $39,000,000 in value.

Although so much space has here been devoted to Dusseldorf, it must not be thought that the city is unique in the diversity of its municipal undertakings or the success with which they are administered. Mr. Howe's book shows us that in these respects it is characteristic of all large German cities.

"The German city is free to own almost anything, free to control the individual and his property, free to borrow, free to experiment, free to develop as it wills. Its bonds to the state rests so lightly that it is almost unconscious of its chains. The citizen is a subject of the city, just as he is a subject of the state and empire.

"Under the laws of the state the German city can do anything it is not expressly forbidden to do, or that the central administrative authorities do not forbid. Generally speaking it can do anything an individual can do."

The German city is the justification of the expert, for it is governed by experts who devote their lives to that profession.

"Men prepare themselves for city administration as they do for the law, medicine, or any other profession. They take special courses in the universities or technical schools in law, finances, engineering, town planning, education, or sanitation. On graduation they compete for a municipal post along with other candidates. Sometimes they enter the permanent service from the city council or the state civil administration, or the profession of law. They rise from one position to another or pass from city to city much as a clergyman or professor in this country moves from place to place. In time they hope to become burgomaster, and if they make a success in their city their reputation is known all over Germany. This is true of the burgomaster, of members of the magistrate or administrative council, and of the important permanent officials generally. . . .

"In salary, in social position, in power and opportunity, as well as in permanency of tenure, Germany has provided a system that attracts men of talent and ability to city administration. . . .

"The business men who rule the German city are not the small shopkeepers, as in Great Britain; they are the bankers, merchants, real estate speculators, and professional men. They form the ruling class. They elect the council which in turn elects the burgomaster and members of the magistrat. . . .

"Despite the political power of the business men, they do not legislate in the interest of their class, as they do in America. That is one of the anomalies of Germany, for I know of no other country in the world in which this is true." . . .

Civil service is a delusion. Tenure of office does not make citizens either beautiful, healthy, intelligent, moral or industrious. It may have exactly the opposite effect, it perpetuates incompetency. Some of the most inefficient employees I have ever saw were the civil service

*Abstracts from an address delivered before the Civic League of Cleveland, February 28th, 1914.

[1] Deaths of infants under 1 year, per 1,000 births, 1910—Seattle, 82; Cleveland, 150. (Census Bureau.)

[2] National Board of Fire Underwriters' Report for 1912.

incumbents in Washington. Among many of them it is not good form to be either intelligent or industrious.

A commission form of government? This may be a distinct step backward. An honest, competent commission may be better than a dishonest mayor and incompetent board of aldermen, but to substitute a collective executive for an individual executive is to weaken one of the fundamental principles of organization, namely, localized responsibility and authority.

The best form of organization in the world is found in modern marine service, and next to that is a great modern office building, which is probably evolving the future city type. The administration of a great office building, like that of a great ship, is simple and successful because there are a few definite aims and ideals and everything else is made subservient to them. In both cases, we have a competent head of the line, with full responsibility. He is surrounded by a staff; he could not for an hour perform his duties without staff help, and the staff and line together carry out the work.

Line gives the skeleton of administration and authority. Staff gives universal knowledge. Line without staff never has sufficient knowledge. Staff without line never has organization. Staff corresponds to a dictionary, line corresponds to grammar. The practical difficulty with unstandardized men is that the line thinks it has knowledge and the staff thinks it has authority.

Therefore the three practical requirements for good city government are:

High Ideals,
Reasonable Standards,
Their Attainment

through a strong administration of line and staff.

Acoustics of Auditoriums—II*

An Investigation of the Acoustical Properties of the Auditorium of the University of Illinois

By Prof. F. R. Watson

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2031, Page 359, December 5, 1914

IV. THE INVESTIGATIONS IN THE AUDITORIUM AT THE UNIVERSITY OF ILLINOIS.

A. PRELIMINARY WORK.

As already stated a chaos of sound was set up when an observer in the Auditorium spoke or shouted or clapped his hands. Both echoes and reverberations were present and could be heard in all parts of the room, though the echoes seemed to be strongest on the stage and in the balcony. The prospects for bettering the acoustics were not very encouraging. Luckily, the cure for reverberation was fairly simple, since Sabine's method gave a definite procedure that could be applied to this case. The cure for the echo, however, was yet to be found. It was first necessary to find out which walls set up the defect.

The attempt to locate echoes by generating a sound and listening with the ear met with only partial success. The ear is sensitive enough but becomes confused when many echoes are present, coming apparently from every direction, so that the evidence thus obtained is not altogether conclusive. It became apparent that the successful solution lay in fixing the attention on the sound going in a particular direction and finding out where it went after reflection; then tracing out the path in another particular direction, and so on until the evidence obtained gave some hint of the general action of the sound.

The first step in the application of this principle was to use a faint sound which could not be heard at any great distance unless reinforced in some way. The ticks of a watch were directed, by means of a reflector (Fig. 2) to certain walls suspected of giving echoes. Using the relation that the angle of incidence equals the angle of reflection, the reflected sound was readily located, and the watch ticks heard distinctly after they had traveled a total distance as great as 70 to 80 feet from the source.

In a later experiment, a metronome was used which gave a louder sound. It was enclosed in a sound-proof

*Abstract of Bulletin 73, of the Engineering Experiment Station. Published by the University of Illinois.

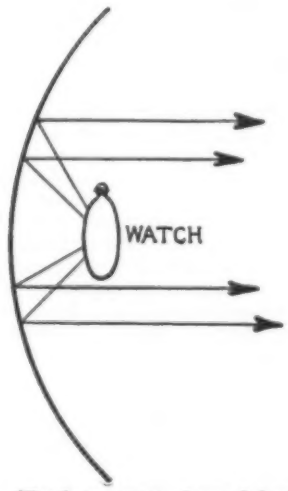


Fig. 2.—Watch as source of sound, backed by concave reflector.

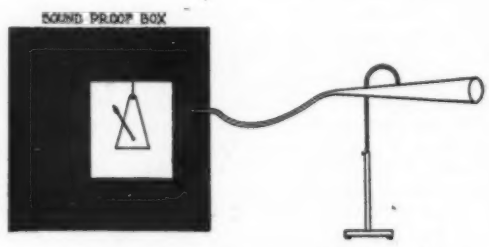


Fig. 3.—Metronome as source of sound.

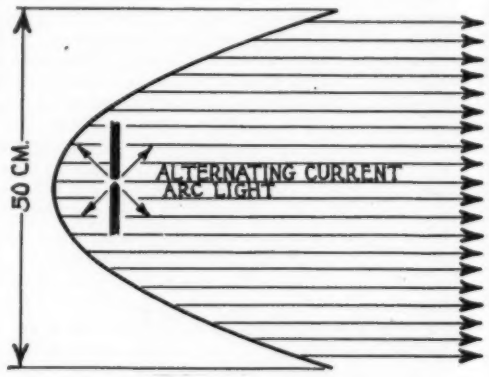


Fig. 4.—Arc light as source of sound.

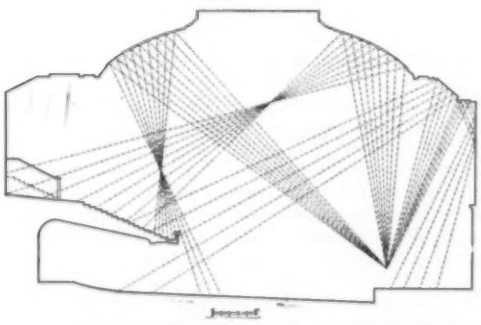


Fig. 5.—Longitudinal section of auditorium, showing the chief concentration of sound, the diffraction effects being disregarded.

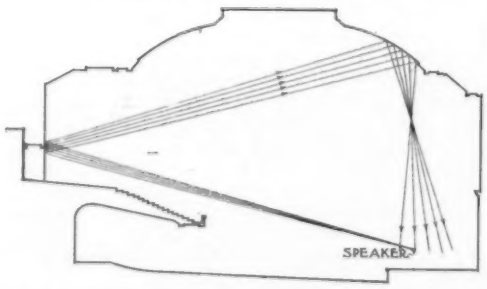


Fig. 6.—Longitudinal section, showing how sound is returned to the stage to form an echo.

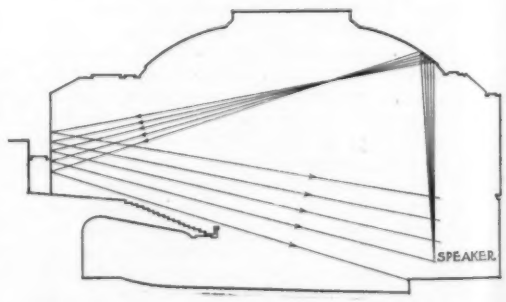


Fig. 7.—Longitudinal section, showing formation of echo on the stage.

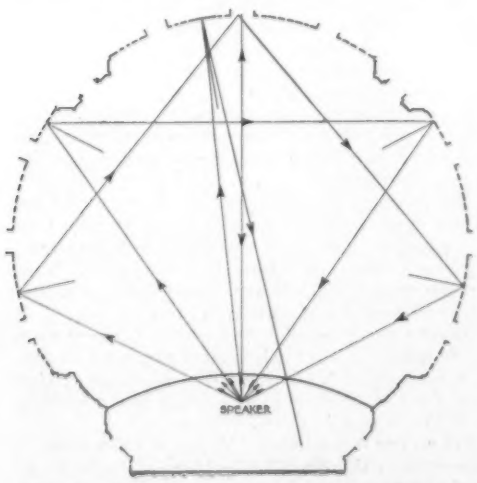


Fig. 8.—Plan of auditorium, showing action of rear wall on the sound.

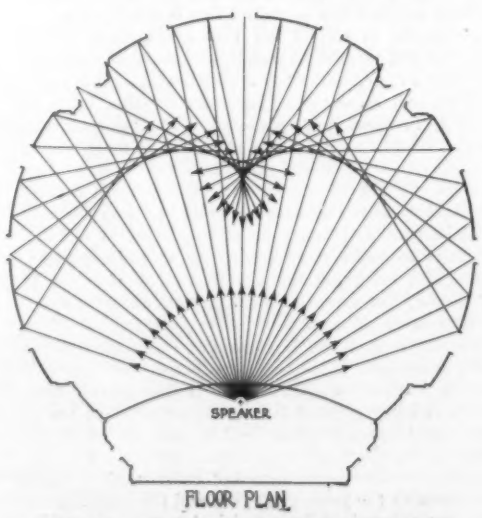


Fig. 9.—Plan of auditorium, showing concentration of sound by the rear wall.

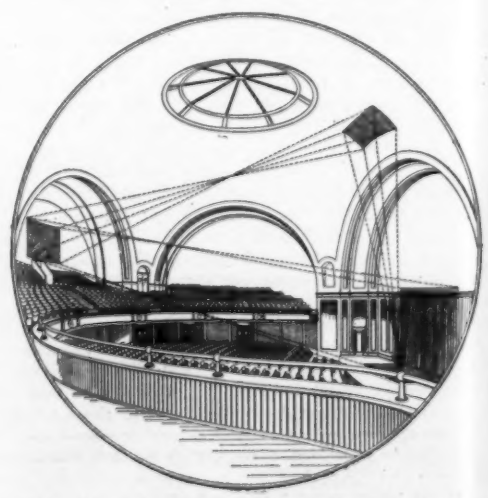


Fig. 10.—This figure, taken with Fig. 7, shows how an echo is set up on the stage.

structure (Fig. 3) with only one opening, so that the sound could be directed by means of horn. This method was suggested by the work of Gustav Lyon in the Hall of the Trocadero at Paris,[17] where a somewhat similar arrangement was used. The method was successful and verified the observations taken previously.

Though the results obtained with the watch and metronome seemed conclusive, yet the observer was not always confident of the results. A further method was sought, and a more satisfactory one found by using an alternating current arc-light at the focus of a parabolic reflector (Fig. 4). In addition to the light, the arc gave forth a hissing sound, which was of short wave length and therefore experienced but little diffraction. The bundle of light rays was, therefore, accompanied by a bundle of sound, both coming from the same source and subject to the same law of reflection. The path of the sound was easily found by noting the position of the spot of light on the wall. The reflected sound was located by applying the relation that the angles of incidence and reflection are equal. The arc-light sound was intense and gave the observer confidence in results that was lacking in the other methods. To trace successive reflections, small mirrors were fastened to the reflecting walls so that the path of the reflected sound was indicated by the reflected light. A "diagnosis" of the acoustical troubles of the Auditorium was then made by this method.

It should be noted here that the arc-light sound is not the same as the sounds of music or speech, these latter ones being of lower pitch and of longer wave length. It was, therefore, a matter of doubt whether the results obtained would hold also for the case of speech or music. Tests made by observers stationed in the Auditorium when musical numbers and speeches were rendered, however, verified the general conclusions obtained with the arc-light.

It should be pointed out in this connection that there is an objection to applying the "ray" method of geometrical optics to the case of sound. It is much more difficult to get a ray of sound than it is to get a ray of light.[18] This is due to the difference in the wave lengths in the two cases. It appears that the waves are diffracted, or spread out, in proportion to their length, the longer waves being spread out to a greater extent. The short waves of light from the sun, for instance, as they come through a window mark out a sharp pattern on the floor, which shows that the waves proceed in straight lines with but little diffraction or spreading. Far different is it with the longer waves of sound. If the window is open, we are able to hear practically all the sounds from outdoors, even that of a wagon around the corner, although we may be at the other end of the room away from the window. The longer sound waves spread out and bend at right angles around corners, so that it is almost impossible to get a sound shadow with them. Furthermore, in the matter of reflection, it appears that the area of the reflecting wall must be comparable with the length of the waves being deflected. In the case of light, the waves are very minute, hence a mirror can be very small and yet be able to set up a reflection; but sound waves are of greater length, the average wave length of speech (45 cm.) being about 700,000 times longer than the wave length of yellow light (.00006 cm.), hence the reflecting surface must be correspondingly larger. An illustration will perhaps make this clearer. Suppose a post one foot square projects through a water surface. The small ripples on the water will be reflected easily from the post, but the larger water waves pass by almost as if the post were not there. The reflecting surface must have an area comparable with the size of the wave if it is to cause an effective reflection. Relief work in auditoriums, if of small dimensions, will affect only the high pitched sounds, i. e., those of short wave length, while the low pitched sounds of wave length are reflected much the same as from a rather rough wall. It is also shown that the area of the reflecting surface is dependent on its distance from the source of sound and from the observer; the greater these distances are the larger must be the reflecting surface.[19]

These considerations all show that the reflection of sound is a complicated matter. The dimensions of a wall to reflect sound, or of relief work to scatter it, are determined by the wave length and by the various other factors mentioned. It should be said with caution that a "ray" of sound is reflected in a definite way from a small bit of relief work. We must deal with *bundles* of sound, not too sharply bounded, and have them strike surfaces of considerable area in order to produce reflections with any completeness.

B. DETAILS OF THE ACOUSTICAL SURVEY IN THE AUDITORIUM.

The general effect of the walls of the Auditorium on the sound may be anticipated by considering analogous cases in geometrical optics, but with the restrictions on "rays" described in the preceding paragraph. The sound does not actually confine itself to the sharp boundaries shown. The diagrams are intended to indicate the main effect of the sound in the region so bounded. Fig. 5 gives such an idea for the concentration of sound in the longitudinal section of the Auditorium.

The plan followed in the experimental work was to anticipate the path of the sound as indicated in Fig. 5, then to verify the results with the arc-light reflector. Figs. 6 and 7 show the effect of the rear wall in the balcony in forming echoes on the stage. The speaker was particularly unfortunate, being afflicted with no less than ten echoes.

The hard, smooth, circular wall bounding the main floor under the balcony gave echoes as shown in Fig. 8, the sound going also in the reverse direction of the arrows.

A more comprehensive idea of the action of this wall is shown in Fig. 9. This reflected sound was small in amount and therefore not a serious disadvantage.

The cases cited were fairly easy to determine since the bundles of sound considered were confined closely to either a vertical or a horizontal plane for which the plans of the building gave some idea of the probable path of the sound. For other planes, the paths followed could be anticipated by analogy from the results already found. Fig. 10 shows in perspective the development of the result expressed in Fig. 7.

A square bundle of sound starts from the stage and strikes the spherical surface of the dome. After reflection, it is brought to a point focus, as shown, and spreads out until it strikes the vertical cylindrical wall in the rear of the balcony. This wall reflects it to a line focus after which it proceeds to the stage. Auditors on all parts of the stage complained of hearing echoes.

Referring to Fig. 5, it is seen that the arch over the stage reflects sound back to the stage. Fig. 11 shows in perspective the focusing action of this overhead arch. Fig. 12 shows the effect of the second arch. Some of this sound is reflected to the stage and to the seats in front of the stage; other portions, striking more nearly horizontally, are reflected to the side balconies. The echoes

[17] La Nature (Paris), April 24, 1909.

[18] Rayleigh "Theory of Sound," Vol. II, 283.

[19] Rayleigh, Ibid. 283.

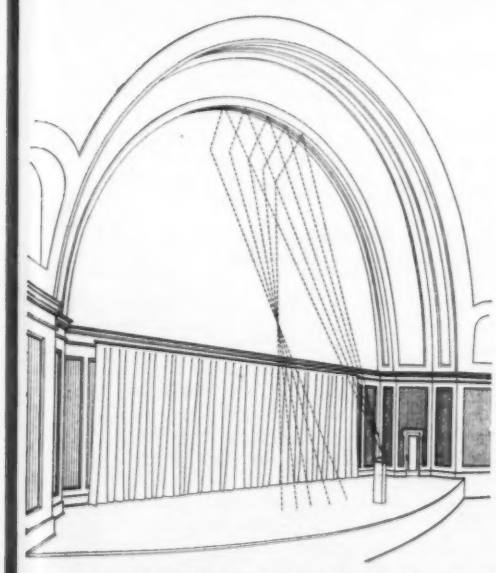


Fig. 11.—Perspective of stage, showing focusing action of arch on sound.

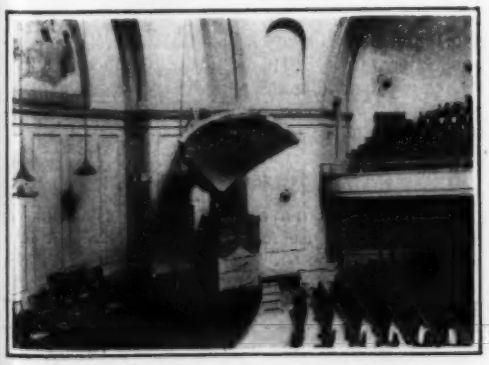


Fig. 16.—Hard plaster reflector and pulpit.

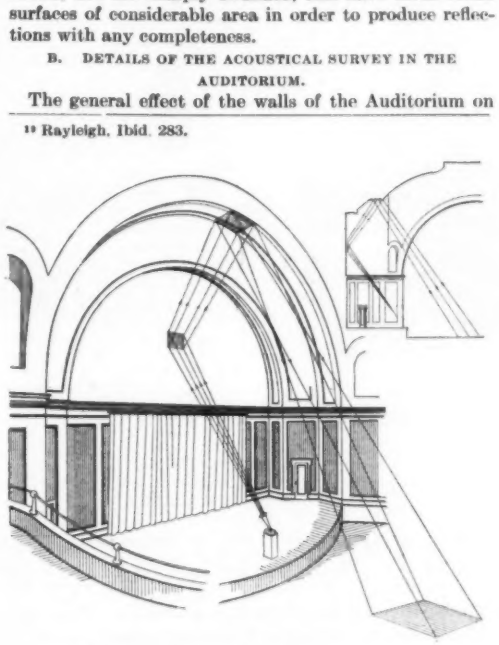


Fig. 12.—Perspective of stage, showing focusing action of second arch.

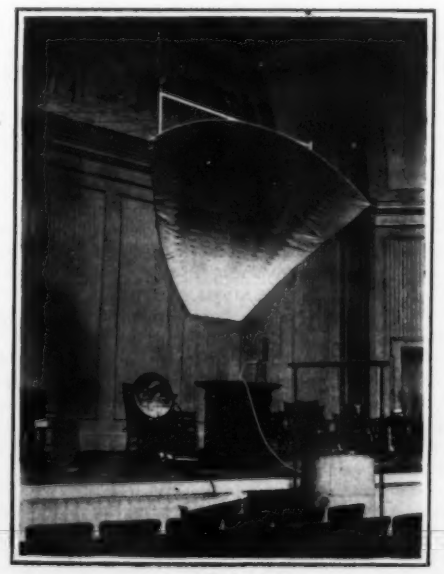


Fig. 18.—Large parabolic reflector.

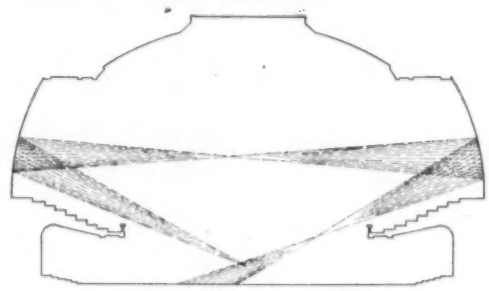


Fig. 13.—Transverse section of auditorium, showing how most pronounced echoes are set up by the two concave surfaces.

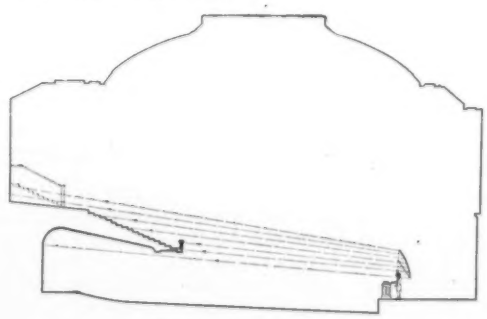


Fig. 17.—Parabolic reflector, showing its action on sound.

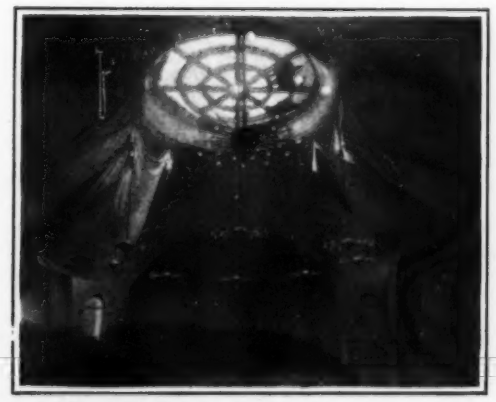


Fig. 19.—Canvases hung to eliminate echoes.

are not strong except for high pitched notes with short wave lengths, since the width of the arch is small.

Passing now to the transverse section, Fig. 13, we find the most pronounced echoes in the Auditorium. If an observer generates a sound in the middle of the room directly under the center of the skylight, distinct echoes are set up. A bundle of sound passes to the concave surface which converges the sound to a focus, after which it spreads out again to the other concave surface and is again converged to a focus nearly at the starting point. The distance traveled is about 225 feet, taking about ¼ second, so that the conditions are right for setting up a strong echo. This echo is duplicated by the sound which goes in the reverse of the path just described. Another echo, somewhat less strong, is formed by the sound that goes to the dome overhead and which is reflected almost straight back, since the observer is nearly at the center of the sphere of which the dome is a part. These echoes repeat themselves, for the sound does not stop on reaching the starting point but is reflected from the floor and repeats the action just described. As many as ten distinct echoes have been generated by a single impulse of sound.

The echo shown in Fig. 13 is repeated in a somewhat modified form for a sound generated on the stage by a speaker. Fig. 14 shows the path taken by the sound. This echo is duplicated by the sound that goes in the reverse direction of the arrows, so the speaker is greeted from both sides. The sound does not confine itself closely to a geometrical pattern, as shown in the picture, but spreads out by diffraction. The main effect is shown by the figure.

Thus far only the echoes that reached the stage have been described. Other echoes were found in other parts of the hall, and it seemed that few places were free from them. The side walls in the balcony, for instance, were instrumental in causing strong echoes in the rear of the balcony. Fig. 15 shows in perspective the action of one of these walls. These two surfaces were similar in shape and symmetrically placed. Each was the upper portion of a concave surface with its center of curvature in the center of the building under the dome. The general effect of the left hand wall was to concentrate the sound falling on it in the right hand seats in the balcony. Some of the sound struck the opposite wall and was reflected to the stage, as shown in Fig. 14. Auditors who sought the furthermost rear seats in the balcony to escape echoes were thus caught by this unexpected action of the sound. The right hand wall acted in a similar way to send the sound to the upper left balcony.

The dome surface concentrates most of its sound near the front of the central portion of the balcony and the ground floor in front of the balcony in the form of a caustic cone. Figs. 5, 6, and 7 give some conception of how a concentration of sound is caused by this spherical surface. The echo in the front portion of the balcony was especially distinct. On one occasion, in this place, the author was able to hear the speaker more clearly from the echo than by listening to the direct sound.

Minor echoes were set up by the horizontal arch surfaces in the balcony. The sound from the stage was concentrated by reflection from these surfaces and then passed to a second reflection from the concave surfaces back of them. Auditors in the side balcony were thus disagreeably startled by having sound come from overhead from the rear.

C. CONCLUSION DRAWN FROM THE ACOUSTICAL SURVEY.

The results of the survey show that curved walls are largely responsible for the formation of echoes because they concentrate the reflected sound. It seems desirable, therefore, to emphasize the danger of using such walls unless their action is annulled by absorbing materials or relief work. Large halls with curved walls are almost sure to have acoustical defects.

D. METHODS EMPLOYED TO IMPROVE THE ACOUSTICS.

Reflecting Boards.—The provisional cure was brought about gradually by trying different devices suggested by the diagnosis. In one set of experiments sounding boards of various shapes and sizes were used. A flat board about five feet square placed at an incline over the position of the speaker produced little effect. A large canvass surface, about 12 by 20 feet, was not much better. A parabolic reflector, (Fig. 16) however, gave a pronounced effect. This reflector was mounted over a pulpit at the end of the stage and served to intercept much of the sound that otherwise would have gone to the dome and produced echoes. The path of the reflected sound was parallel to the axis of the paraboloid of which the reflector was a quarter section. There was no difficulty in tracing out the reflected sound. Auditors in the path of the reflected rays reported an echo, but auditors in other parts of the Auditorium were remarkably free from the usual troubles. The device was not used permanently, since many speakers objected to the raised plarform. Moreover, it was not a complete cure, since it was not suited for band concerts and other events, where the entire stage was used. Another reflector similar in shape to the one just described is shown in Figs. 17 and 18.

Sabine's Method.—The time of reverberation was determined by Sabine's method. An organ pipe making approximately 526 vibrations a second was blown for about three seconds and then stopped. An auditor listened to the decreasing sound, and when it died out made a record electrically on a chronograph drum. The time of reverberation was found to be 5.90 seconds, this being the mean of 19 sets of measurements, each of about 20 observations. The reverberation was found also by calcualtion from Sabine's equation (see Section III), taking the volume of the Auditorium as 11,800 cubic meters and calculating the absorbing power of all the surfaces in the room. This calculation gave 6.4 seconds. The agreement between the two results is as close as could be expected, since neither the intensity of the sound nor the pitch used by the author was the same as those used by Professor Sabine, and both of these factors affect the time of reverberation.

Several years later the time of reverberation was again determined after certain changes had been made. A thick carpet had been placed on the stage, heavy velour curtains 18 by 32 feet in area hung on the wall at the rear of the stage, a large canvass painting 400 square feet in area was installed, and the glass removed from the skylight in the ceiling. The time of reverberation was reduced to 4.8 seconds. With an audience present this value was reduced still more, and when the hall was crowded at commencement time the reverberation was not troublesome.

Method of Eliminating Echoes.—Although the time of reverberation was reduced to be fairly satisfactory, as just explained, the echoes still persisted, and were very annoying. Attempts were made to reduce individual echoes by hanging cotton flannel on the walls at critical points. Thus the shaded areas in Fig. 14 were covered and also the entire rear wall in the balcony. Pronounced echoes still remained, and it was evident that some drastic action was necessary to alleviate this condition. Four large canvasses, shown in Fig. 19, were then hung in the dome in positions suggested by the results of the diagnosis. A very decided improvement followed. For the first time the echoes were reduced to a marked degree and speakers on the stage could talk without the usual annoyance. This arrangement eliminated the echoes not only on the stage, but generally all over the house. A number of minor echoes were still left, but the conditions were much improved, especially when a large audience was present to reduce the reverberation.

Proposed Final Cure.—The state of affairs just described is the condition at the time of writing. Two propositions were considered in planning the final cure. One proposition involved a complete remodeling of the interior of the Auditorium. Plans of an interior were drawn in accordance with the results of the experimental work that would probably give satisfactory acoustics. This proposition was not carried out because of the expense and because it was thought desirable to attempt a cure without changing the shape of the room. The latter plan is the one now being followed. It is proposed to replace the present unsightly curtains with materials which will conform to the architectural features of the Auditorium and which will have a pleasing color scheme. At the same time, it will be necessary to hold to the features which have improved the acoustics.

Note.—Since the above report was issued certain alterations suggested by Prof. Watson's experiments have been made. These consist largely in the building of a false ceiling and side walls of suitable material, following approximately the original lines, and eighteen inches distant therefrom. The results were entirely satisfactory, as every sound is now distinctly audible throughout the building, and there are no disturbing echoes.

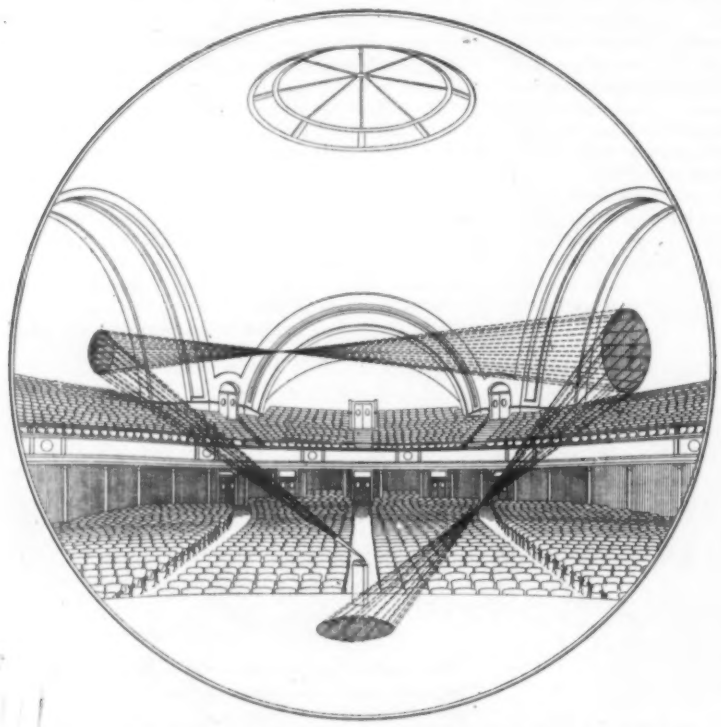


Fig. 14.—Perspective showing how an echo is formed on the stage by two reflections. Diffraction effects are not considered in the drawing.

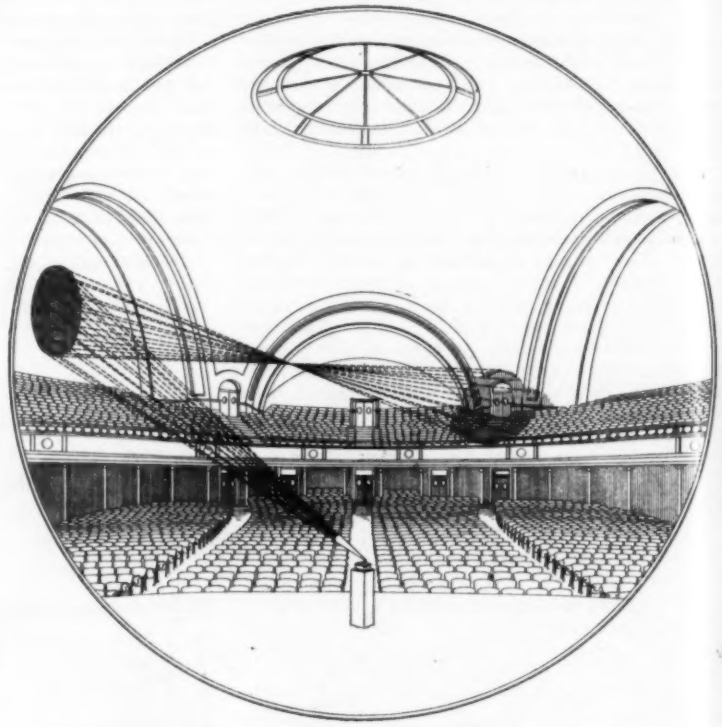


Fig. 15.—Perspective showing sound reflected from concave wall in balcony. Diffraction not considered.

Glazed Frost

SPEAKING of "glazed frost," by which is meant the smooth coating of ice formed when super-cooled raindrops strike objects, Dr. T. Okada, in the *Journal* of the Meteorological Society of Japan, says: "The conduction and evaporation of raindrops falling through ice-cold layers of the atmosphere will be sufficient to cool them many degrees below the freezing point." The difficulty appears to be to explain why small drops do not solidify in falling through the air.

The Gulf Stream*

Causes That Governs Its Course, and Its Effect on Climate

MANY theories have been advanced to account for ocean currents in general and for the Gulf Stream in particular. Their causation has been attributed by various writers to: (1) Differences in the temperature and density of the sea in widely separated geographical positions. (2) Differences in level due to inequalities in different regions of evaporation and precipitation; and to the overflow of great rivers. (3) To convection currents. (4) To the rotation of the earth on its axis. (5) To the direct action of persistent winds.

Wind is the prime cause of all currents; persistent winds the motive power to which all the great ocean streams may be assigned. If anyone be in doubt as to the fact, let him place tracings of maps on which the direction of the principal current of the globe in the different months or seasons of the year are indicated, over maps on the same scale on which wind distribution, referable to the same months or seasons, is shown, and it will be seen how closely the currents follow the direction of the wind, and how quickly the former respond to changes in the direction of the latter.

In this connection the course of equatorial current of the Indian Ocean, on the western side of the Arabian Sea, may be cited as a striking example. During those months when the north-east monsoon prevails the current in that region turns to the southward and joins the Mozambique current, but as soon as the change in the direction of the wind occurs, and even before the south-west monsoon is established, the current swings round and flows in the new direction of the wind, to the northward and eastward.

All winds by friction cause some movement of the water surfaces over which they blow, while the waves, and even the wavelets they raise, add impulse to the motion; the stronger the wind the greater being its effect at the time. This surface movement caused by wind is gradually imparted to the water layer below it, and when the wind persists in the same direction for long, the motion is transmitted from layer to layer to a considerable depth.

Under the influence of the trade winds, the currents when nearing equatorial regions probably extend to a depth of from 200 to 400 feet.

Although the principal currents are produced and maintained by the action of persistent winds, their direction is largely controlled by the rotation of the earth on its axis and by variation in temperature and in density, also in evaporation and precipitation in different geographical positions; but these exert only slight local modifying effects. Moreover, as regards the Gulf Stream and its causation, it was found by the officers of the United States Coast Survey that the Atlantic Ocean at Sandy Hook was 3 to 4 feet lower than the waters of the Gulf of Mexico at the mouth of the Mississippi. This difference of level, which is said to have been ascertained by accurate measurements, doubtless is caused by the heaping up of water in the gulf by the equatorial current; and the power requisite for maintaining the constant flow of the Gulf Stream through the Strait of Florida must, in a large measure, be attributed to this agency.

The warm, relatively high salinity water which undoubtedly exercises an ameliorating effect upon the climate of our islands and upon that of northwestern Europe generally is mainly of equatorial origin, and is directly attributed to the agency of the Gulf Stream.

In support of this belief, let me refer you, in the first place, to a chart of surface temperature of the North Atlantic in order to show what evidence the distribution of mean annual surface temperature will reveal.

The effect of the collision between the Gulf Stream and the cold Labrador current is boldly marked by the steep temperature gradient from 40 degrees to 46 degrees north. Now trace the course of the isotherms onward. The isotherm of 50 degrees, which on the 50th meridian is in 43 degrees north latitude, on the 28th meridian is in 60 degrees north; the isotherm of 52 degrees, which on the 50th meridian is situated only a few miles south of the 50 degree isotherm, on the 10th meridian is in 57 degrees north; but the isotherm of 60 degrees, which on the 50th meridian is in about 41½ degrees north, reaches the coast of Portugal, after making a curve northward, in about the same latitude. In other words, the surface temperature of the Atlantic between the 43rd and 60th parallels, and the 4th and 32nd meridians is the same as that which is found on the 50th meridian between the 41st and 43rd parallels, where the Gulf Stream and Labrador current meet.

Now let us see what corroborative evidence a chart of average salinity will afford.

In the northern portion of the North Atlantic, the southern portion of the Greenland sea, and the part of the Barents Sea which are enclosed by the 35th and 36th isohalines, are filled with water of the same salinity as that which we find in the Gulf Stream between Cape Hatteras and its place of meeting with the current from the north.

Whether the relatively warm saline stream, or any part of its waters which flows north-eastward from the region south of the Great Bank, is derived from that stream which issues for the most part from the Gulf of Mexico, or, as some aver, is an independent stream which takes its origin in the former locality, is a question which must remain unsettled until the results of further investigations are available. This, at the least, we know, that from the Strait of Florida northward and north-north-eastward to the edge of the Bank; thence north-eastward, as well as eastward, across the ocean, aided, no doubt, by the prevailing westerly and south-westerly winds, there exists throughout the year a continuous flow of warm saline, or relatively warm saline water, to the north-easterly branch of which these islands owe much of their salubrity.

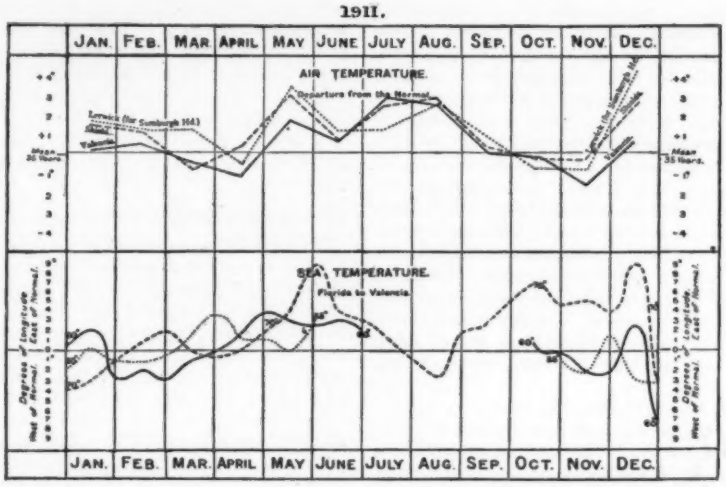
The salubrity of our climate is, of course, largely due to its comparatively mild and even temperature. The relatively small annual range of temperature that obtains normally results from our insular position; the warmth we owe also in a large measure to the surrounding sea, which receives much of its heat from that ocean stream, the course of which we have been following.

I will endeavor to show you by means of diagrams the somewhat frequent correlation of sea temperature with the air temperature over our islands during the decade 1903-1912. In order to confine within manageable limits that portion of the inquiry which relates to sea-surface temperature, the North Atlantic is represented by a broad zone situated between Florida Strait and Valencia in the south-west of Ireland. It happens that the changes in surface temperature, which may be regarded as of premier importance in this connection, occur in this zone.

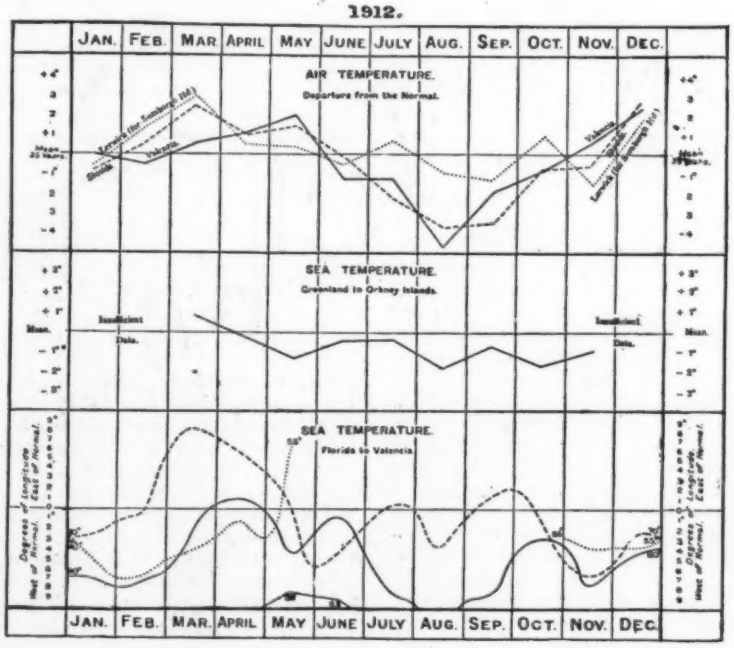
In the diagrams relating to sea temperature in this Florida-Valencia zone, the excess or defect in the surface temperature is expressed by the number of degrees of longitude in which the 70 degree, 60 degree, and 55 degree isotherms are east or west of their average limit for the month.

Air temperature over our islands is represented, roughly it must be admitted, by the temperature registered at three stations, widely separated: Valencia, Sumburgh Head, in the Shetlands, and North Shields. The curves exhibiting changes in temperature at these places show departures from the normal in degrees Fahrenheit, by reference to the scales above and below a line which represents the average of numerous observations extending over a period of thirty-five years.

1911.


JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.
AIR TEMPERATURE.
Departure from the Normal.
SEA TEMPERATURE.
Florida to Valencia.
JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.

1912.


JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.
AIR TEMPERATURE.
Departure from the Normal.
SEA TEMPERATURE.
Greenland to Orkney Islands.
Insufficient Data.
SEA TEMPERATURE.
Florida to Valencia.
JAN. FEB. MAR. APRIL MAY JUNE JULY AUG. SEP. OCT. NOV. DEC.

The salient features exhibited in the years 1911 and 1912 are as follows:

Sea temperature in the northern half of the ocean is shown to have been slightly in excess of the normal in January; but, as indicated by the 70 degree isotherm, in defect, but increasing, in the southern half. Subsequently it increased to above normal in the south-western Atlantic until the end of February, and declined to the north-eastward during that month. The conditions were reversed in March, a fall in temperature taking place to the south-west, and a rise to the north-eastward. Over the aera represented by the 60 degree and 70 degree isotherms temperature rose in April, but

*From a lecture delivered before the Royal Geographical Society by Commander M. W. Campbell Hepworth, C. B.

declined to the north-eastward. After April sea temperature was in excess of the normal until October, except in the south-west portion of the ocean, when the 70 degree isotherm retreated to the west of its average limit in August. The temperature in this part, however, quickly recovered, the 70 degree isotherm, which was nearly 9 degrees of longitude to the east of its average limit at the end of May, again advanced, and was 7 degrees east of it in October, and 9 degrees in December; but retreating rapidly towards the close of the month. Increased activity of the Labrador current in the two closing months of the year reduced the sea temperature for the most part below the normal in the northern portion of the ocean, although south of the 44th parallel it temporarily rose more than 2 degrees above.

As regards air temperature during the year 1911, in the months of January and February, from the close of April to the close of September, and again in December, the temperature of the air over Great Britain and Ireland was in excess of the average; moreover, during the months of May, July, August, and December, it was greatly in excess. In October the temperature was about the same as the average, and in March, April, and November only can it be said to have been in defect.

Throughout the greater part of the year 1912 the curves of air temperature resemble, in a marked degree, those relating to sea surface temperature.

Sea Temperature.—The temperature of the sea surface, which fell below the normal at the close of the previous year, continued in defect during the first three months of the year under notice, except in the south-western portion of the North Atlantic, whereit rose above the normal after the middle of February. The temperature then increased so quickly that in less than a month the 70 degree isotherm was charted 8 degrees to the east of its average limit for March. In the more northern portions of the ocean, the surface temperature, although in defect until after March, rose from the middle of February until April, and in that month the charted results exhibited for the most part, an excess of temperature over the North Atlantic generally. The abnormally warm water, of equatorial origin, that was advancing north-eastward, and had been most noticeable in the south-western Atlantic in March, and between the 40th and 50th parallels of latitude in the following month, reached the north-eastern Atlantic in May, flooding the costal waters off our southern shores, while a decided reduction of surface temperature was taking place in other parts of the ocean.

At the end of May, and in the beginning of June, the 70 degree isotherm had retreated 6 degrees to the west of its average limits for those months, but a slight temporary recovery of temperature was observed between the 40th and 50th parallels up to the middle of the latter month, when under the cooling influence of the Labrador current the surface temperature rapidly declined, the 60 degree isotherm in August having retreated as much as 13 degrees of longitude to the west of its average limit. In the south-west arm of the ocean the temperature rose during June and July, reaching the average toward the close of the latter month, when it declined, but recovered in September. It again declined during the two months that followed, in the latter of which it became considerable in defect; and, although the sea surface temperature increased in the second half of November, it continued to be below the normal to the end of the year.

To the north-eastward the isotherm of 60 degrees, and subsequently that of 55 degrees, indicated a decided defect in surface temperature to the end of the year; albeit fluctuations are shown which harmonize with the temperature of the surface water to the south-westward, as indicated by the 70 degree isotherm.

For the zone between South Greenland and the Orkneys sufficient data are wanting for the purpose of comparison with normal results, until March, when the surface temperature is shown to have been slightly above the normal. It declined during the following two months, when it stood 1½ degrees below the normal, but it rose to, and remained, ½ degree below the normal in June and July; fell under the influence of the East Greenland Current in August; recovered somewhat in the month following; and exhibited similar fluctuations as those which obtained in August and September during the two remaining months, for which sufficient data are available.

The air temperature over the British Isles during the summer and autumn of 1912, in contrast with that prevailing during the same seasons of the previous year, is found, therefore, to have been below the normal in June to November inclusive, except at the northern station in July and October and at the south-western station in November, at which places it rose slightly above the respective months. It was above the normal in February to May inclusive, except at Valencia, when the excess did not obtain until March; equal to, or nearly equal to, the normal in January, and above in December; at Valencia above in November also.

There appears to be no justification for the assumption that important changes have taken place in the circulation of the North Atlantic during historic times. The velocity and volume of the Gulf Stream exhibit modifications that are non-periodic as well as seasonal—modifications that may occur during any month in any year. When the Stream is abnormally active, its resistance to the Labrador current is probably carried farther north than usual, with the result that its north-easterly branch pursues its course in higher latitudes than obtains normally, and its relatively warm saline waters penetrate to the north-westward of their average limits. When, on the other hand, the Gulf Stream is weaker than is usual, according to the season, the converse happens; the north-easterly branch of the Stream commences its new course after its collision with the arctic current, in lower parallels than those in which it commonly starts, and, possibly, the easterly branch is augmented at the expense of the former; so that the influence of the Stream may be restricted in two ways.

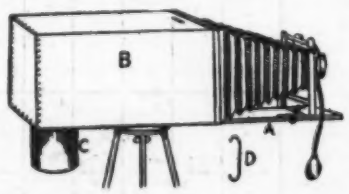
In connection with an investigation undertaken at the Meterological Office, having for its object a comparison of the changes in the strength of the trade winds of the Atlantic[1] with average results, and of changes in the surface temperature of the North Atlantic with normal values, there was found to be some evidence to prove that departures from the average strength of the two trade winds during a series of months, and at times during even so short a period as one month, were roughly reflected in deviations from the normal through the agency of the equatorial current and Gulf Stream in the average distribution of surface temperature in the North Atlantic in the corresponding series of months or month, as the case may be, of the succeeding year, notwithstanding the existence of many other causes affecting the temperature of the surface water, which must tend towards masking the appearance of such connection.

Proof may, therefore, be claimed, resting on a chain of evidence, that many of the climatic changes to which our islands are subject owe their origin to modifications in the trade winds of the Atlantic, communicated through the agency of the equatorial current and its giant offspring the Gulf Stream.

A Positive Postcard Camera

A WRITER in the *Camera* tells how to make an apparatus that can be applied to any camera that will enable the so-called "positive postcards" to be made, and these are a great convenience when only a few copies of the scene are wanted. Of course, the special developer sold for use with these cards must be used, but the apparatus the user can make for himself. This is the description given:

A is the camera, with back removed; *B* is the box, made to fit camera; *C* is a tank to hold the developer. The cards are dropped into this through a slot in the bottom of the box *B*. This tank may be of hard rubber, or glass-lined. I made mine by cutting off the top of a square bottle, and making a box of thin wood to fit around the lower portion of the bottle. The tank should have a flange extending around the top, so that



it may be held firmly in place by two buttons on the bottom of the box *B*. *D* is a piece of tin a quarter inch wider than the postcards and a half inch shorter. The two sides are bent around for an eighth of an inch, as shown in *D*. This is fastened in the front end of the box *B* so that it will be exactly in the center. The card is placed into this form on top. The focus will have to be adjusted so that the pictures will be sharp. A few trials will be required to get this, after which the distance should be marked on the front bed of the camera.

I then took a focussing-cloth a yard square, and fastened the two sides together so as to form a sack with both ends open. One end of this I tacked around *B* as shown by the dotted lines. On the other end I fastened several glove-fasteners, so that when I placed my hand inside I could button this up tight around my arm so as to exclude all light. A tripod-socket and a direct-vision view-finder were then put in place, and a box large enough to hold a package of postcards was made with a lightproof lid, and fastened inside of *B*, on one side near the back.

French Bullets Humane

AS CONTRASTED with the numerous statements that have been circulated that poisoned bullets have been used by the French troops, it is a pleasure to note a report on the subject by Prof. Walther Straube in the *Munchener Medizinische Wochenschrift*. During the battles around Mulhausen many French cartridges were found in which the bullets had a black band where they fitted into the shell, and this was commonly believed by the German soldiers to be of a poisonous nature. A number of these cartridges were submitted to Prof. Straube for examination, and he reports that this band is a harmless ring of lacquer. He goes on to state that the bullets themselves are composed of copper, zinc and nickel, and that on analysis they were found to contain no arsenic, phosphorus or antimony, and consequently "of very good material." Furthermore, he says that the copper jacket is so very thin that it is incapable of doing any damage if split off from the core, being a mere film, and therefore the bullets could not be "dum-dumed" by nicking or filing the nose. The conclusion reached by this authority is that "as far as the expression may be allowable, the French bullet must be regarded as humane." This was also the verdict of German army surgeons, who have found the wounds made by these bullets comparatively trivial, and far different from those made by the German and English "spitz" bullets.

It may be safely remarked that none of the nations involved have officially used illegitimate bullets of any kind.

[1] The Trade Winds of the Atlantic Ocean.

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